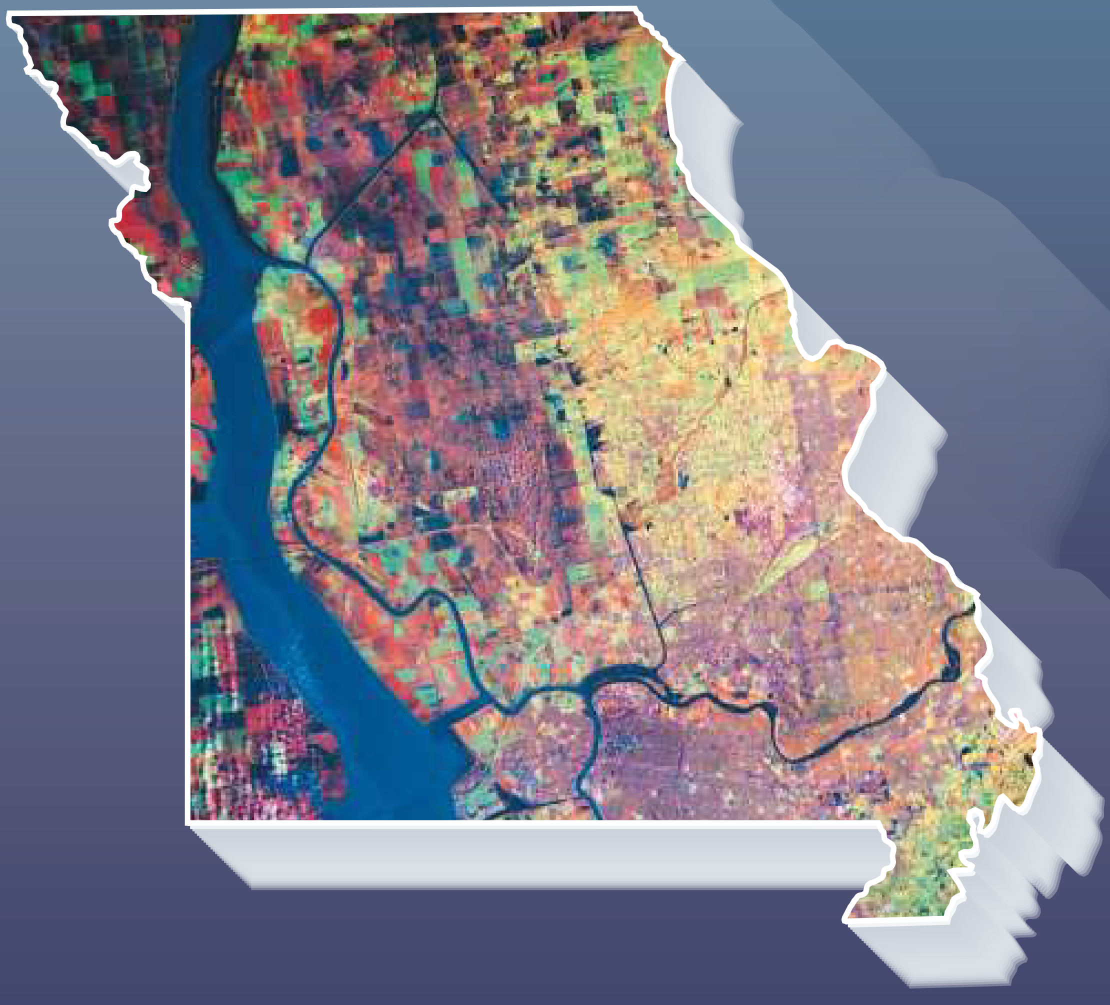
MISSOURI STATE

HAZARD MITIGATION PLAN 2023



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Organization

The 2023 Missouri State Hazard Mitigation Plan is written in accordance with, and is generally organized according to, the guidance set forth in the State Mitigation Planning Policy Guide, effective April 2023. The plan is divided into an executive summary and seven sections briefly summarized below:

- **Executive Summary** – Provides user friendly access to the state mitigation goals, objectives, actions and hazard profiles.
- **Section 1, Prerequisites** – This section includes details of the formal adoption of the plan update as well as a summary of the plan's compliance with Federal and State laws and regulations.
- **Section 2, Planning Process** – This section explains the planning process that was followed to prepare the plan update, including how it was prepared, who was involved, and how it was integrated with other related planning efforts.
- **Section 3, Risk Assessment** – This section features the risk assessment which identifies the type and location of hazards that can affect Missouri, analyzes the State's vulnerability to the hazards identified, and serves as the factual basis for the mitigation strategy.
- **Section 4, Comprehensive State Hazard Mitigation Program** – This section provides the State's mitigation blueprint. Specifically, in includes goals and objectives, State and local capabilities, mitigation activities, and funding sources.
- **Section 5, Coordination of Local Mitigation Planning** – This section describes the State's role in funding, developing, coordinating, and approving local mitigation plans, and how the state prioritizes funding for local mitigation plans and projects.
- **Section 6, Plan Maintenance** – This section presents the method the State Risk Management Team (SRMT) uses to monitor, evaluate, and update the plan. It also introduces how the team monitors project implementation and closeouts and reviews progress on achieving goals.
- **Section 7, Enhanced Plan** – This section is the "enhanced" portion of the plan and documents Missouri's project implementation capabilities and commitment to a comprehensive mitigation program.

Executive Summary

Across the United States, natural, manmade, and other disasters have led to increasing numbers of deaths, injuries, property damages, and disruptions of business and government services. This can take an immense toll on people, businesses and government, especially in these challenging economic times. The time, money and effort to respond to and recover from disasters divert public resources and attention from other important programs. As of January 2022, Missouri has had a total of 56 federal Presidential Disaster Declarations and 8 Emergency Disaster Declarations since 1975. Missouri recognizes the consequences of disasters and the need to reduce the impacts of natural, human-caused/technological, and other disasters.

Hazard mitigation is defined by the Federal Emergency Management Agency (FEMA) as any action taken to eliminate or reduce the long-term risk to human life and property from hazards and their effects. This is crucial to the residents, businesses, and governments of Missouri. Hazard Mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage, reconstruction, and repeated damage.

People and property in Missouri are at risk to a variety of hazards. Among other hazards, Missouri is at risk to tornadoes, floods, drought, earthquakes, severe winter weather, and wildfires. These hazards have the potential to cause widespread loss of life and damage to property, infrastructure, and the environment.

- *One-page profiles of each natural and human-caused hazard are presented here within the Executive Summary.*
- *The web-based Missouri Hazard Mitigation Viewer provides local planners or other interested parties access to all of the State Plan risk assessment datasets. The Viewer can be accessed here: http://bit.ly/MoHazardMitigationPlanViewer2023*

Missouri recognizes the potential consequences of disaster events. The need to reduce these impacts through property planning and preventative measures is of great importance to the State and its residents.

This Missouri State Hazard Mitigation Plan update is an important planning component of state-level programs for management of disasters and their impacts. It considers years of mitigation experience and a variety of mitigation initiatives. It has also taken advantage of the collective mitigation knowledge of many state, federal, and local officials as well as multiple stakeholders throughout the private sector. As such, implementation of this plan is positioned to significantly contribute to mitigation of negative impacts from future Missouri disasters.

This plan also summarizes the methods the State will use to prioritize cost-effective mitigation measures. The current priorities include local hazard mitigation planning, acquisition of floodprone properties, relocation/retrofitting of floodprone properties, floodplain management, tornado safe rooms, flood and earthquake structural projects, and technical assistance. Both short-term and long-term hazard mitigation measures are identified and prioritized to help all state and local agencies allocate appropriate resources in a responsible manner that will provide for the health, safety, and general welfare of all people in Missouri.

- *The State Mitigation Planning goals, objectives, and actions are presented here within the Executive Summary.*

This plan will continue to provide a general blueprint for hazard mitigation activities in Missouri and is structured to serve as the basis for specific hazard mitigation efforts for multiple hazards. It is done so in a manner that meets federal requirements for mitigation planning and that complies with collaboratively developed national standards for emergency management. As such it is approved by FEMA and accredited by the Emergency Management Accreditation Program (EMAP).

State Mitigation Goals and Objectives

The following hazard mitigation goals and objectives frame and focus the State of Missouri's mitigation strategy. The goals and objectives guide the state mitigation program and the selection of actions to mitigate potential losses from hazard events. The goals and objectives represent a long-term vision for hazard reduction and enhancement of mitigation capabilities and have evolved over years of mitigation planning in Missouri.

Goal 1: Preserve *human life, health, and safety* from the adverse effects of disasters

1.1. Maintain a robust mitigation program that addresses ways to mitigate the ***loss of life*** from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety, and reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

1.2. Increase public awareness of disaster risks and effective mitigation measures that protect ***human life*** in cooperation with SEMA's mitigation partners.

1.3. Support the development of sensible enabling legislation, programs, and capabilities of federal, state, and local governments and public-private partnerships engaged in mitigation activities.

1.4. Maintain a high level of mitigation proficiency among SEMA staff.

Goal 2: Defend the *continuity of government and essential services and processes* from the adverse effects of disasters

2.1. Support the development of sensible mitigation projects to protect key and ***essential facilities and services***.

2.2. Continue to educate federal, state, and local public officials; educational institutions; private associations; and private business entities that provide essential services about hazards and how mitigation can reduce losses and help maintain continuity.

2.3. Educate state and local officials concerning the need to use sensible mitigation techniques for new facility construction.

2.4. Encourage maximum participation in maintaining effective state and local mitigation plans, disaster plans, and business continuity plans.

2.5. Encourage federal, state, and local officials; educational institutions; private associations; and private business entities that provide essential services to incorporate mitigation into other plans.

Goal 3: Protect *public and private property* from the adverse effects of disasters

3.1. Maintain an effective mitigation program that addresses ways to mitigate the ***loss of property*** from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety and reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

3.2. Increase public awareness of disaster risks and effective mitigation measures that protect ***public and private property*** in cooperation with SEMA's mitigation partners.

3.3. Support organizations that work to help mitigate the adverse effects of disasters.

3.4. Support the National Flood Insurance Program, Community Rating System (CRS), earthquake insurance, and other programs that serve to reduce the impacts of disasters on properties.

Goal 4: Safeguard *community tranquility* from the adverse effects of disasters

4.1. Develop, implement, and complete mitigation projects as expeditiously, effectively, efficiently, and unobtrusively as possible.

4.2. Consider sustainability issues (ecologically sound, economically viable, socially just, and humane) when developing or reviewing mitigation projects and plans.

4.3. Lead and support the work of mitigation partners to educate the general public about how mitigation can help protect communities and promote ***community tranquility***.

4.4. Develop and provide periodic reports and success stories to federal, state, and local public officials, educational institutions, private associations, private business entities, and the public on the progress of hazard mitigation activities.

4.5. Encourage citizens and citizen organizations to support and use mitigation in plans, projects, and public outreach to increase a sense of community security and safety.

State Mitigation Actions

To meet identified goals and objectives, the plan recommends the mitigation actions summarized in the table on the following pages. An implementation plan was also developed for each action, which identifies priority level, background information, ideas for implementation, responsible agency, timeline, cost estimate, potential funding sources, and more.

Hazard Profile Summaries

The Hazard Profiles and State Risk Assessment address the following hazards:

- Natural Flood-Related Hazards
  - Flooding
  - Levee Failure
  - Dam Failure
- Natural Geologic Hazards
  - Earthquake
  - Land Subsidence / Sinkholes
- Natural Meteorological Hazards
  - Drought
  - Extreme Temperature
  - Severe Thunderstorms
  - Severe Winter Weather
  - Tornadoes
- Natural Other Hazard
  - Wildfire
- Human-Caused / Technological Hazards
  - Civil Disorder
  - Cyber Disruption
  - Environmental Health Emergencies
  - Fires (Urban/Structural)
  - Hazardous Materials
  - Mass Transportation Accidents
  - Nuclear Power Plants
  - Public Health Emergencies
  - Special Events
  - Terrorism
  - Utilities (Interruptions and System Failures)

For quick reference, one-page summaries of each hazard are presented at the end of this executive summary and include the following components.

- Description/Location
- Extent
- Probability of Future Hazard Events
- Severity
- Location
- State Vulnerability Overview
- Changing Future Conditions Considerations
- Risk Summary/Problem Statement

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
1.	M1	Track local community hazard mitigation plans to ensure completion of new plans and updates to existing plans as their 5-year cycle expires.	SEMA Mitigation Section	COG's RPC's	44	High	Ongoing for 2023	This will continue with the 2023 update.	HMA, SEMA Operating Budget
2.	M1	Provide technical assistance, planning assistance, and available funding to RPCs to develop new and updated local community plans, using the latest FEMA guidance materials, the SEMA-developed plan outline, and SEMA-led workshops which emphasized the use of NFIP risk assessment products to identify local mitigation projects. Track workshops provided.	SEMA Mitigation Section	COG's RPC's	47	High	Ongoing for 2023	The revision updates assistance to include "planning" and identifies SEMA developed local mitigation plan outline and associated workshops.	HMA, SEMA Operating Budget
3.	M9	Use RPCs and SEMA staff to encourage and track the inclusion of floodplain management strategies to mitigate risk associated with eligible HHPDs.	SEMA Mitigation Section	COG's RPC's	47	High	New for 2023	New action to support the identification of mitigation actions to reduce vulnerabilities to/from eligible HHPDs.	SEMA Operating Budget
4.	M9	SEMA and MoDNR will conduct quarterly meetings to discuss the High Hazard Potential Dams Program (HHPD). Discussions will include: vulnerabilities and consequences, dam incidents, deficiencies, mitigation actions, challenges, possible solutions to lack of resources to administrating the HHPD grant.	MoDNR	SEMA Mitigation Section	47	High	New for 2023	New action to reduce the vulnerabilities from eligible high hazard potential dams that pose an unacceptable risk to the public.	MoDNR and SEMA Operating Budget
5.	M1	Use RPCs and SEMA staff to encourage and track implementation of actions in local plans. Submit to the "RAT" FEMA Regional Action Tracker.	SEMA Mitigation Section	COG's RPC's	47	High	Revised for 2023	The revision incorporates tracking of actions.	SEMA Operating Budget
6.	M1	Continue to refine and enhance vulnerability assessments for natural hazards, for example incorporation of changing future conditions data.	SEMA Mitigation Section	SRMT; Other agencies with pertinent data.	48	High	Ongoing for 2023	With the 2023 Update, vulnerability assessments were completed for all 22 hazards. New data will continue to enhance the vulnerability section as future updates are completed.	HMA, SEMA Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
7.	M2	Continue to encourage new participation in the NFIP and CRS programs with a special focus on communities within PIR (Paper Inventory Reduction) Counties which have not previously been mapped but are now being updated and encourage existing participants to promote and enforce their floodplain management programs. Track number of new participating communities.	SEMA Floodplain Mgmt Section	FEMA	48	High	Ongoing for 2023	NFIP and CRS will continue to be encouraged and promoted in Missouri with an updated focus on communities within PIR counties.	CAPSSE, HMA, SEMA Operating Budget
8.	M2	Provide a reference and/or support for local communities to implement CRS activities. Track distribution of CRS materials.	SEMA Floodplain Mgmt Section	FEMA	47	High	New for 2023	Keep support tools related to CRS activities up-to-date including local mitigation planning tools, quick guide references, website, etc.	CAPSSE, HMA, SEMA Operating Budget
9.	M3	Publish all statewide vulnerability assessment results, including HAZUS-MH results to RPCs and local governments for mitigation planning purposes and to promote consistency in the updates to local plan risk assessments.	SEMA Mitigation Section	COG's RPC's	47	High	Revised for 2023	The 2023 Plan Update included the development of a website to publish vulnerability assessment result to jurisdictional level.	SEMA Operating Budget
10.	M3	As FEMA/SEMA pioneer into the use of 2D modeling, support and provide technical assistance for FEMA Risk MAP Products to communicate risk and promote mitigation actions. Track workshops providing training and technical assistance for 2D products.	SEMA Floodplain Mgmt Section and Mitigation Section	FEMA	47	High	Revised for 2023	For 2023, incorporate the use of SEMA developed RiskMAP User Guide and associated workshops addressing 2D modeling.	SEMA Operating Budget
11.	M3	Support and coordinate the development of real-time technical assistance projects (alternative analyses) as identified during Risk-MAP modeling updates.	SEMA Floodplain Mgmt Section	FEMA	48	High	New for 2023	This action is a collaboration of the Risk MAP effort with mitigation and is a priority for the State.	SEMA Operating Budget
12.	M4	Employ the Loss Avoidance Tool, first developed as part of the 2018 Plan Update, for acquisition and safe room locations following Disaster Declarations to track avoided losses associated with each event.	SEMA Mitigation Section	FEMA	47	High	Ongoing for 2023	Incorporate new disaster information for the loss avoidance tool created with 2018 plan.	HMA, SEMA Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
13.	M5	Continue to pursue mitigation of flood-prone properties through implementation of the Repetitive Loss Strategy and development/implementation of a Statewide Buyout Strategy. Track reduction in repetitive loss structures.	SEMA Mitigation Section	DED; CDBG	49	High	Ongoing for 2023	Severe Repetitive Loss Properties & Repetitive Loss Properties continue to be a top priority for property buyouts in Missouri with additional focus on the developed strategy. Implement statewide buyout strategy in 2023.	HMA, CDBG, BRIC
14.	M6	Support the construction of tornado safe rooms in local communities' public buildings, public schools, and eligible private non-profit facilities to FEMA standards.	SEMA Mitigation Section	COG's RPC's DESE, DHE, non-profit organizations	49	High	Ongoing for 2023	This is a priority, following flood buyout properties, for grant funds in Missouri & continues to be updated in the 2023 Plan Update.	HMA, CDBG, BRIC
15.	M7	Support the Missouri Statute "Earthquakes - Seismic Building and Construction Ordinances," to require public buildings in the State of Missouri to be designed in accordance with building codes based upon the latest version of the National Earthquake Hazards Reduction Program (NEHRP) provisions for the design of new buildings.	SEMA MoDNR	COG's RPC's	46	Medium	Ongoing for 2023	This is a priority in Missouri & and continues to be supported through SEMA efforts.	SEMA and MoDNR Operating Budget
16.	M7	Support the distribution of Public Education materials regarding Earthquake/High Wind nonstructural mitigation measures. Participate in annual Great ShakeOut earthquake drills.	SEMA MoDNR	COG's RPC's	46	Medium	Ongoing for 2023	These are recognized as significant hazards in Missouri & are supported through SEMA and continue to be updated in the 2023 Plan Update. Action was further described to note distribution of educational materials.	SEMA and MoDNR Operating Budget
17.	M9	Maximize the use of PA mitigation funds in Missouri. Track mitigation funds included with all PA projects.	SEMA Public Assistance Section	FEMA Local Communities	45	Medium	Ongoing for 2023	SEMA will seek to maximize the use of PA mitigation funds in Missouri following disaster declarations.	PA mitigation funds
18.	M14	Educate and encourage local jurisdictions to pursue BRIC funding for community mitigation projects. Track outreach materials and workshops covering BRIC funding opportunities.	COG's RPC's	SEMA	46	Medium	New for 2023	As a new grant program, it is good use of SEMA staffing effort to educate eligible jurisdictions.	BRIC

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
19.	M10	Implement the mitigation actions identified in the comprehensive plan for response and recovery facilities throughout Missouri.	SEMA Response and Recovery Divisions	FEMA Local Communities	45	Medium	Ongoing for 2023	This is recognized as a good use for grant funds in Missouri.	HMA, CDBG, BRIC
20.	M11	Pursue mitigation of state owned/operated facilities which have been identified through the refined risk assessments as at risk.	OA	SEMA, MDC, DHE, MoDOT	45	Medium	Ongoing for 2023	This is recognized as a good use for grant funds in Missouri.	HMA, CDBG, BRIC
21.	M12	Continue to pursue mitigation of municipal and public electric provider's services.	SEMA Mitigation Section	Municipal and public electric providers	38	Low	Ongoing for 2023	This is recognized as a good use for grant funds in Missouri.	HMA, CDBG, BRIC
22.	M13	Support projects that are consistent with the State goals & objectives, but difficult to quantify the benefits using the standard BCA (i.e. warning sirens, permanently installed generators, etc.)	SEMA Mitigation Section	COG's RPC's	42	Low	Ongoing for 2023	This is a consideration for HMGP 5% set aside funds in Missouri.	HMA

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
23.	M14	Support Missouri agencies that own, operate, and/or lease state facilities, continue to improve work to geolocate their facilities as data becomes available to further refine risk assessments using GIS.	OA	SEMA, MDC, DHE, MoDOT	38	Low	Ongoing for 2023	The revision includes all state agencies that own, operate, and/or lease state facilities. This list will continue to be incorporated when this plan is updated every 5 years or as required.	Missouri state funds
24.	M14	Encourage the creation of a State-level Levee Safety Program similar to MoDNR's Dam and Reservoir Safety program.	SEMA MoDNR	COE Silver Jackets	42	Low	Ongoing for 2023	The National Committee on Levee Safety supports the creation of state-level levee safety programs. Mitigation action revised to note Silver Jackets as a supporting agency.	Missouri state funds, COE funds
25.	M13	Continue to coordinate with Dept. of Health and Senior Services for ongoing COVID pandemic/endemic response and recovery needs.	SEMA	DHSS	42	Low	New for 2023	This is a consideration for HMGP 5% set aside funds in Missouri.	SEMA Operating Budget

Note: Supporting Agencies: COE (U.S. Corps of Engineers), COG (Council of Governments), MoDNR (Missouri Department of Natural Resources), FEMA (Federal Emergency Management Agency), MDC (Missouri Department of Conservation), DHE (Department of Higher Education), DHSS (Missouri Department of Health and Senior Services), MoDOT (Missouri Department of Transportation), OA (Missouri's Office of Administration), RPC (Regional Planning Commissions) SEMA (State Emergency Management Agency)

Priority: High denotes action mitigates impacts to life safety and property, moderate denotes action mitigates impacts to life safety only or property only

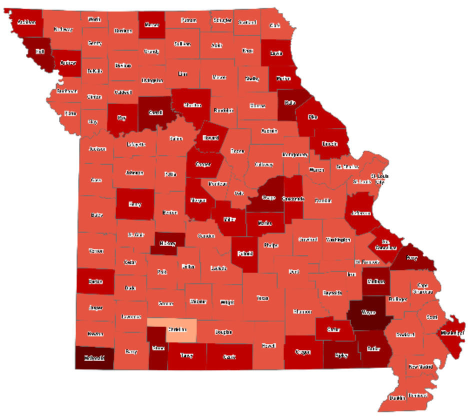
Funding Sources: CDBG (Community Development Block Grant); HMGP (Hazard Mitigation Grant Program); BRIC (Building Resilient Infrastructure and Communities); FMA (Flood Mitigation Assistance); COE (US Corps of Engineers); CAP-SSE (Community Assistance Program–State Support Services Element)

3.3.1. Flooding

Description

A flood is the partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur as a result of dams being breached or overtopped.

Vulnerability



Extent/Range of Intensity

Flood severity categories, as defined by the National Weather Service, describe the severity of flood impacts in the corresponding river reach. The first three of these flood categories—minor, moderate, and major flooding—are bounded by an upper and lower flood stage, with flood stage defined as an established gage height for a given location at which a rise in water surface level begins to create a hazard to lives, property, or commerce.

Probability	Severity	Location
94% 44 Disaster Declarations in 47 years	High	Statewide

State Vulnerability Overview

For the 2023 State Plan Update, SEMA used the most recent release of Hazus, version 6.0, to model flood vulnerability and estimate flood losses for all 114 counties and the City of St. Louis due to depth of flooding.

Changing Future Conditions Considerations

The expected increases in rainfall frequency and intensity are likely to put additional stress on natural hydrological systems and community stormwater systems. Heavier snowfalls in the winter will lead to intensified spring flooding, and groundwater levels will remain high even in non-floodplain areas. Such changes in climate patterns can lead to the development of compounding events that interact to create extreme conditions. Flooding caused by high groundwater levels typically recedes more slowly than riverine flooding, slowing the response and recovery process. Groundwater-fed rivers and streams are also likely to experience heightened flooding when groundwater levels are high.

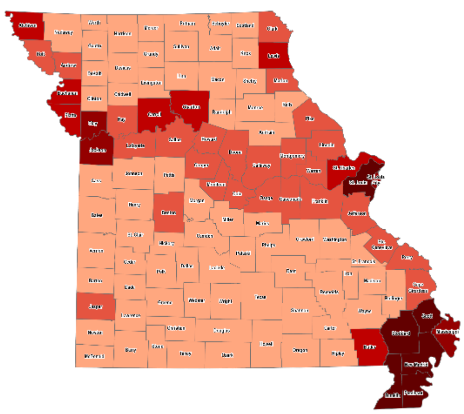
Risk Summary/Problem Statement

Using the indicators of Building Loss, Lost Ratio and Displaced Persons and the top ten counties with the highest risk for these indicators, the data suggests that it would be most feasible to spend effort and dollars on mitigating losses in these top ten locations. Boone, Butler, Clay, Jackson, Jefferson, McDonald, St. Charles, and St. Louis Counties have the highest risk for all 3 of these indicators and are the most vulnerable to the 100-year flood. Clay and Jackson Counties are split by the Missouri River and are heavily populated with Kansas City metropolitan communities. St. Charles and St. Louis Counties are also split by the Missouri River; they are heavily populated with St. Louis City metropolitan communities. Boone and Jefferson Counties border the Missouri River. McDonald County is located in the southwestern corner of the state and is subject to flooding from the Elk River. Mitigation efforts such as buyouts, floodproofing and insurance awareness, implementation of higher regulatory standards, adoption of building codes, participation in the CRS Program, and pre-staging of emergency response resources to reduces losses would be most beneficial to these counties.

3.3.2. Levee Failure

Description

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in loss of life and injuries as well as damages to property, the environment, and the economy.

Vulnerability	Extent/Range of Intensity
	Levee failure can mean either *breaching* or *overtopping* of a levee. A levee breach is when part of the levee structure breaks away leaving an opening for water to rush through. Similar to dam failures, levee failures during flooding events damage assets with the velocity of the water caused by sudden release resulting in a flood surge or flood wave downstream. If the levee is overtopped as a result of flood waters in excess of the levee design, impacts are similar to flood impacts plus water may become trapped behind the levee in unbreeched areas, unable to drain quickly.

Probability	Severity	Location
100% Over 100 events in 80 years	Moderate	Statewide

State Vulnerability Overview

Levees have been constructed across the State of Missouri by public entities and private entities with varying levels of protection, inspection oversight and maintenance. In Missouri, there are currently 182 levee systems in the USACE Levee Safety Program. Of those, 23 are considered to be designed to provide protection from the 1-percent-annual-chance flood event. An additional seven are designed to provide protection from the 0.2-percent-annual-chance flood event. The remaining levees provide protection against lower level flooding that occurs more frequently than the 1-perecent annual chance flood.

Changing Future Conditions Considerations

The impact of changing future conditions on levee failure will most likely be related to changes in precipitation and flood likelihood. Climate change projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on levees and increasing likelihood of levee failure. Furthermore, aging levee infrastructure and a lack of regular maintenance (including checking for seepage and removing trees, roots and other vegetation that can weaken a levee) coupled with more extreme weather events may increase risk of future levee failure.

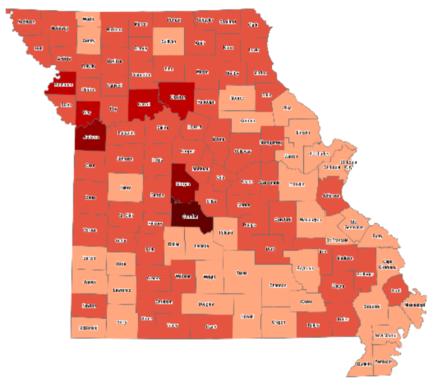
Risk Summary/Problem Statement

The top five counties most impacted for building loss from levee failure are Pemiscot, Dunklin, New Madrid, Scott and Butler counties. Focusing mitigation efforts and dollars in these five counties would most likely prove the most successful strategy.

3.3.3. Dam Failure

Description

A dam failure is characterized by an uncontrolled release of water from behind a dam. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, and terrorism can all cause a dam to fail. When a dam failure occurs, an enormous amount of water is suddenly released, destroying infrastructure and flooding the area downstream of the dam.

Vulnerability	Extent/Range of Intensity
	A dam failure is characterized by an uncontrolled release of water from behind a dam. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, and terrorism can all cause a dam to fail. When a dam failure occurs, an enormous amount of water is suddenly released, destroying infrastructure and flooding the area downstream of the dam.

Probability	Severity	Location
45% 19 events in 42 years	Moderate	Statewide

State Vulnerability Overview

The downstream hazard classification system utilized by the National Inventory of Dams provides the Hazard Classification system as a means to determine overall vulnerability in the event of dam failure. According to the NID, of the 5,363 recorded dams, 1,460 (27.2%) are High Hazard, 182 (3.4%) are Significant Hazard and 3,721 (69.4%) are Low Hazard. If any of the 1,460 High Hazard dams in the state were to fail, loss of human life is likely. If any of the 182 Significant Hazard dams were to fail, loss of human life is possible. Failure of any of the 3,721 low hazard dams can result in loss of property, but loss of life is unlikely.

Changing Future Conditions Considerations

The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario.

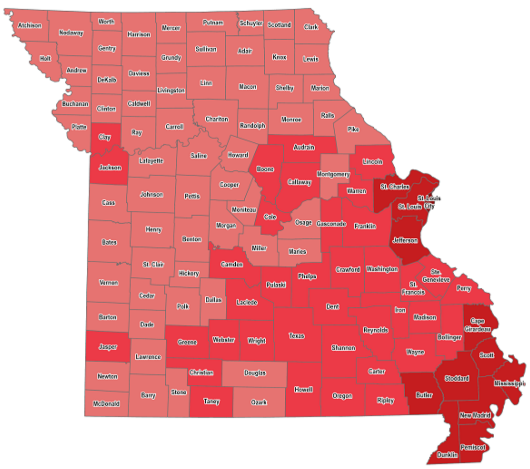
Risk Summary/Problem Statement

The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario. Using the indicators of potential residential losses due from either State or USACE dam failure, the top five counties affected are Jackson, Greene, Clay, Boone and Cass counties.

3.3.4. Earthquake

Description

Earthquakes are defined as shifts in the earth's crust causing the surface to become unstable. This instability can manifest itself in intensity from slight tremors to large shocks. The duration can be from a few seconds up to five minutes. The period of tremors (and shocks) can last up to several months. The larger shocks can cause ground failure, landslides, liquefaction, uplifts, and sand blows.

Vulnerability	Extent/Range of Intensity
	The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. The Richter Magnitude Scale is used to quantify the magnitude or strength of the seismic energy released by an earthquake. Another measure of earthquake severity is Intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity Scale.

Probability	Severity	Location
65% 32 events in 49 years	High	Statewide, predominately Bootheel area of State

State Vulnerability Overview

According to MoDNR's Missouri Geological Survey, damage from earthquakes in the New Madrid Seismic Zone will vary depending on the earthquake magnitude, the character of the land, and the degree of urbanization. The Bootheel area is dominantly rural with scattered small to medium-sized towns. Damage to the land could be extensive and significantly affect the area's farming industry. The more distant, densely populated urban area of St. Louis is not likely to have damage to the land, but its huge stock of structures and their contents could receive significant damage from shaking and earthquake-triggered landslides and sinkhole collapse. Shaking would be most severe to development built on thick, clay-rich soils. Roads and railroads in southeast Missouri and Saint Louis area could be severely damaged by earthquake triggered slope failures, rockfalls, and liquefaction.

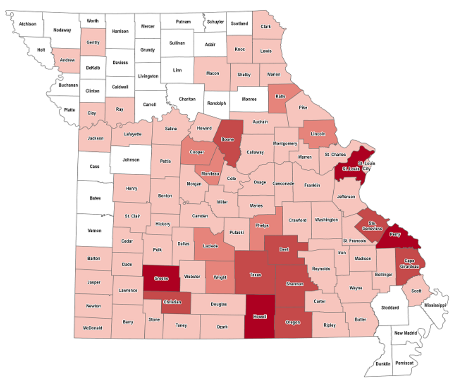
Changing Future Conditions Considerations

Scientists are beginning to believe there may be a connection between changing climate conditions and earthquakes. Changing ice caps and sea-level redistribute weight over fault lines, which could potentially have an influence on earthquake occurrences. However, currently no studies quantify the relationship to a high level of detail, so recent earthquakes should not be linked with climate change. While not conclusive, early research suggests that more intense earthquakes and tsunamis may eventually be added to the adverse consequences that are caused by changing future conditions.

3.3.5. Land Subsidence/Sinkholes

Description

Land subsidence is a geological hazard caused by the sinking of the earth's surface due to the movement of earth materials below the surface. This sinking can be sudden or gradual and is generally attributed to the removal of subsurface water or the draining of organic soils. In Missouri, subsidence is primarily associated with sinkholes, but they can also occur from void space left by mining and natural caves.

Vulnerability	Extent/Range of Intensity
	There is no scale for measuring or determining the severity of sinkholes. However, geological and mining parameters can affect the magnitude and extent of sinkhole subsidence. Natural sinkholes develop in areas where the rock below the surface is limestone, carbonate rock, salt beds or any type of rock that can naturally be dissolved by groundwater circulating through it. Artificial sinkholes develop due to groundwater pumping, water main and sewer collapses, and mine collapses.

Probability	Severity	Location
83%	Low	Predominately southern portion of State

Location

St. Louis City and St. Louis County, Greene, Christian, St. Charles, Perry and Ste. Genevieve

State Vulnerability Overview

Sinkholes vary in size and location. These factors will determine the impact of the hazard, which could manifest as the loss of a personal vehicle, a building collapse or damage to infrastructure such as roads, water or sewer lines. Because of the relationship of sinkholes to groundwater, pollutants captured in sinkholes (or dumped) can affect a community's groundwater system. Sinkhole collapse could be triggered by large earthquakes, which could be particularly problematic for the St. Louis metropolitan area. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

Changing Future Conditions Considerations

Direct effects from changing climate conditions such as an increase in droughts and could contribute to an increase in sinkholes. These changes raise the likelihood of torrential rain and flooding conditions which often lead to the exposure of sinkholes. Certain events such as a heavy precipitation following a period of drought can trigger a sinkhole due to low levels of groundwater combined with a heavy influx of rain.

Risk Summary/Problem Statement

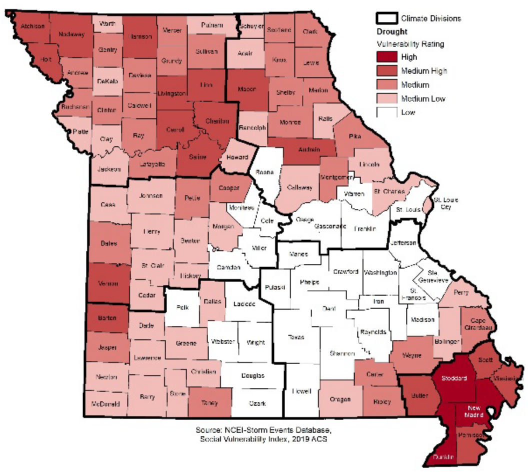
Often, the geographical extent of this hazard is known, as such mitigation can be targeted. Avoiding the hazard is much more cost effective than altering or mitigating the sinkhole itself. Mitigation efforts and dollars focused on counties listed above would be most feasible.

3.3.6. Drought

Description

The National Weather Service defines drought as "a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people." Droughts are regional climatic events which can impact large areas ranging from several counties in Missouri to the entire Midwestern region. Droughts can adversely affect a small town's water supply, homeowners, small business owners, commodity markets, and tourism.

Vulnerability



Extent/Range of Intensity

The Palmer Drought Severity Index (PDSI) is one of the most common and longest-used indicators of drought severity. The PDSI measures the difference between water supply (in terms of precipitation and stored soil moisture) and demand (the amount of water required to recharge soil and keep rivers, lakes, and reservoirs at normal levels). The scale is from +4 to -4. Missouri has been susceptible to all levels of PDSI drought, including extreme moist spell (+4) to extreme drought (-4).

Probability	Severity	Location
6-11%	High	Statewide

State Vulnerability Overview

The agricultural sector suffers the greatest impacts during times of drought in Missouri. Areas prone to expansive soils can have greater movement during drought conditions that can impact foundations and infrastructure. Drought, as it affects the health and safety of Missouri citizens, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems at levels that have caused impacts to some smaller communities.

Changing Future Conditions Considerations

The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating that the periods between heavy rainfalls will be marked by an increasing number of dry days. Higher temperatures and increased evapotranspiration increase the likelihood of drought. This could lead to agricultural drought and suppressed crop yields.

Risk Summary/Problem Statement

The impacts of drought are diffuse and far-reaching. Sector impacts beyond agriculture include water supply and quality, relief, response, and restrictions, plants and wildlife, business and industry and tourism and recreation. Severe drought also poses health threats to citizens due to water shortages and can be exacerbated by extreme heat. Particularly vulnerable are children, the elderly, and those with respiratory problems.

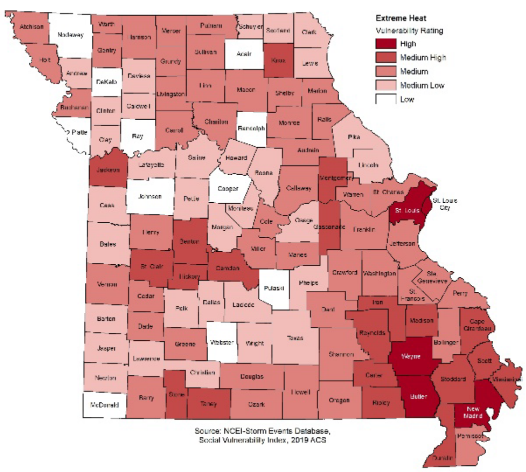
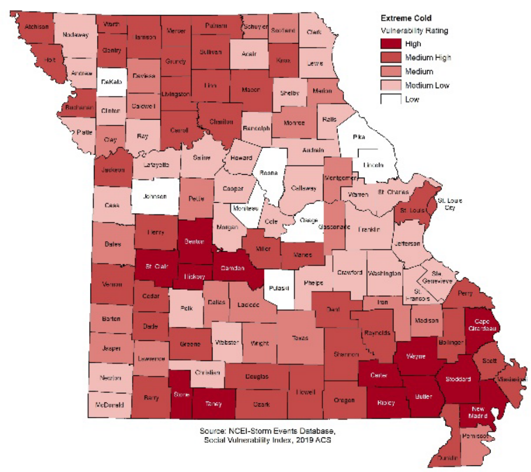
3.3.7. Extreme Temperatures

Description

Frequent changes in temperature are known to occur mainly because of the State's inland location. Extreme heat can be described as temperatures that hover 10°F or more above the average high temperature for a region during the summer months. Extreme cold temperatures drop well below what is considered normal for an area during the winter months and often accompany winter storm events.

Extent/Range of Intensity

Prolonged periods of extremely cold weather or heat are unusual, however temperatures above 100° F have occurred, as well as, temperatures below 0° F. The National Weather Service (NWS) issues heat-related and wind chill/freeze warnings, watches, advisories, and outlooks. The NWS local offices in Missouri may collaborate with local partners to determine when an alert should be issued for a local area.

Vulnerability – Extreme Heat	Vulnerability – Extreme Cold
	

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

The three counties rated "High" in overall vulnerability to extreme heat include Butler, New Madrid, and Wayne, and also the City of St. Louis. There were 13 counties that rated "High" in overall vulnerability to extreme cold: Benton, Butler, Camden, Cape Girardeau, Carter, Hickory, New Madrid, Ripley, St. Clair, Stoddard, Stone, Taney, and Wayne.

Changing Future Conditions Considerations

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the century. Temperature increases will cause future heat waves to be more intense, a concern for this region which already experiences hot and humid conditions. If the warming trends continue and cold wave intensity is projected to decrease.

Risk Summary/Problem Statement

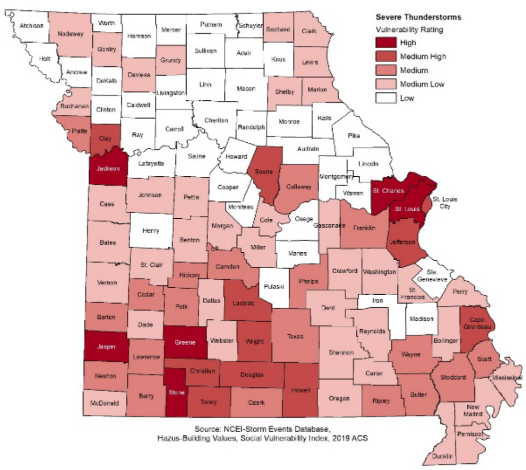
Citizens of Missouri should be instructed to be aware of the warning signs of heat-related illness, such as light-headedness, mild nausea or confusion, sleepiness, or profuse sweating. Extreme cold can also be life threatening and cause injury and death due to hypothermia.

3.3.8. Severe Thunderstorms (includes damaging winds, hail, and lightning)

Description

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. The National Weather Service defines a thunderstorm as severe if it contains hail that is one inch or the wind gusts are at 58 mph or higher. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time.

Vulnerability – Severe Thunderstorms



Extent/Range of Intensity

The entire State of Missouri is at risk to the damaging effects of Severe Thunderstorms. A severe thunderstorm can produce winds that can cause as much damage as a weak tornado and these winds can be life threatening. Hail associated with thunderstorms can be three quarters of an inch or more in diameter and fall at speeds more than 100 mph. ll thunderstorms produce lightning which often strikes outside of the area where it is raining and is known to fall more than 10 miles away from the rainfall area.

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

Possible impacts include risk to life and property in both the public and private sectors. Public utilities and manufactured housing developments will be especially prone to damages. Jurisdictions already affected should prioritize mitigation actions such as construction of safe rooms for vulnerable populations, retrofitting and/or hardening existing structures, improving warning systems and public education, and reinforcing utilities and additional critical infrastructure. The five counties that rated “High” in overall vulnerability to Severe Thunderstorms include Greene, Jackson, Jasper, St. Charles, St. Louis, and Stone Counties.

Changing Future Conditions Considerations

Predicted increases in temperature could help create atmospheric conditions that are fertile breeding grounds for severe thunderstorms and tornadoes in Missouri. NASA’s Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. Possible impacts include an increased risk to life and property in both the public and private sectors.

Risk Summary/Problem Statement

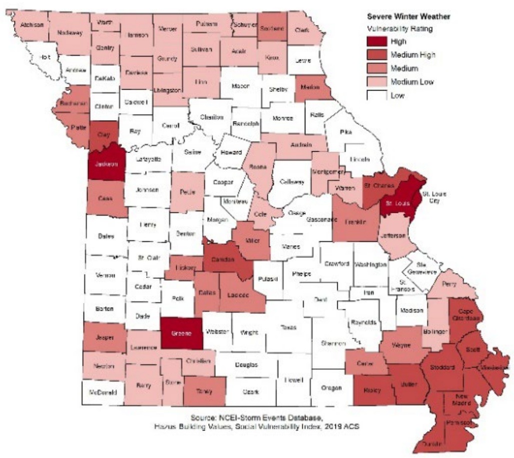
Severe thunderstorms losses are usually attributed to associated hazards of hail, downburst winds, lightning and heavy rains. Losses to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside the State capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are accounted for in the riverine flooding profile.

3.3.9. Severe Winter Weather

Description

Severe winter weather, including snowstorms, ice storms, and extreme cold, can affect any area of Missouri. These events can interact to cause many hazards. Severe winter weather, such as snow, ice storms, and extreme cold can cause injuries, deaths, and property damage in a variety of ways.

Vulnerability – Severe Winter Weather



Extent/Range of Intensity

Weather data indicates that the Missouri counties north of the Missouri River receive an average annual snowfall of 18 to 22 inches. Counties south of the Missouri River receive an annual average of 8 to 12 inches. The events that involve borderline conditions of freezing rain and ice are highly unpredictable. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. The durations of the more serious events combined with other factors, such as high winds, are also highly unpredictable.

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

People living areas south of the Missouri River have a lower probability of experiencing severe winter weather, however, households in this area may have homes with inadequate insulation, fail to maintain an adequate supply of home heating fuels, and be generally under prepared. Of winter deaths related to exposure to cold, 50 percent were over 60 years old. Counties with the most vulnerable populations are St. Louis City and Jackson, Greene and St. Louis Counties. Using Annualized Winter Weather Damages and Loss Ratios as key indicators, the most vulnerable counties are Dallas, Camden, Greene, Jackson, and St. Louis, along with the City of St. Louis.

Changing Future Conditions Considerations

A shorter overall winter season and fewer days of extreme cold may have both positive and negative indirect impacts. As both temperature and precipitation increase during the winter months, freezing rain will be more likely. Additional wintertime precipitation in any form will contribute to saturation and increase the risk and/or severity of spring flooding. A greater proportion of wintertime precipitation may fall as rain rather than snow.

Risk Summary/Problem Statement

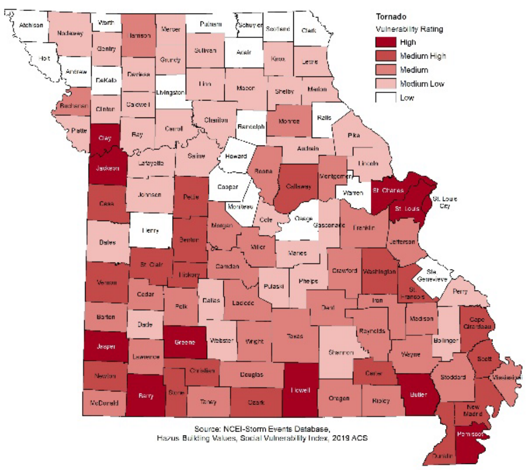
As previously noted, snowstorms, ice storms, and extreme cold can interact to cause many hazards. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. Wind speed may be the difference between a minor snow and a blizzard. These events cannot be prevented. Preparedness for these events may be the greatest single factor to reduce loss of life, injury, and property damage. NOAA weather broadcasts via radio and television provide important information for people to prepare and thus reduce risks to their lives and property.

3.3.10. Tornados

Description

Tornadoes are cyclical windstorms often associated with the Midwestern areas of the United States. Weather conditions conducive to tornadoes often produce a wide range of other dangerous storm activities, including severe thunderstorms, downbursts, straight-line winds, lightning, hail, and heavy rains.

Vulnerability – Tornados



Extent/Range of Intensity

Historically, Missouri has experienced numerous tornadoes of varied intensities. On average, a tornados touchdown lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. About 2,772 tornadoes occurred in Missouri from 1950 to December 31, 2021, with 402 deaths and over $5.3 billion in damage.

Probability	Severity	Location
100%	High	Statewide

State Vulnerability Overview

Many tornados are capable of great destruction. Tornadoes can topple buildings, roll mobile homes, uproot trees, hurl people and animals through the air for hundreds of yards, and fill the air with lethal, windblown debris. With growing population and increased development, there is potential for increased losses as a result of the increase in exposure. But this will be dependent on where the severe thunderstorms occur which is a variable that cannot be predicted due to the random nature of this hazard. Using Overall Vulnerability to Tornado as a key indicator, the most vulnerable counties are Barry, Butler, Clay, Greene, Howell, Jackson, Jasper, Pemiscot, St. Charles, and St. Louis, as well as, the City of St. Louis.

Changing Future Conditions Considerations

Scientists do not know how the frequency and severity of tornadoes will change. Changes in heat and moisture content in the atmosphere, brought on by a warming world, could be playing a role in making tornado outbreaks more common and severe in the U.S. The number of days with large outbreaks have been increasing since the 1950s and that densely concentrated tornado outbreaks are on the rise. Areas already subject to tornado activity are seeing more densely packed tornadoes.

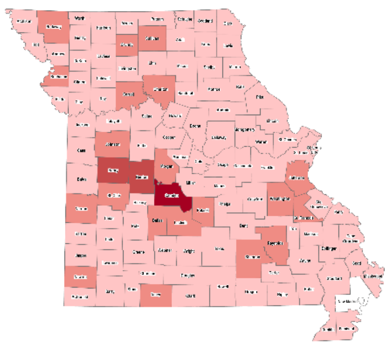
Risk Summary/Problem Statement

The potential severity of effects from tornadoes will continue to be high. Missouri will continue to experience deaths, injuries, and property damage from tornadoes. However, technological advances will facilitate earlier warnings than previously available. This, combined with a vigorous public education program and improved construction techniques, provides the potential for significant reductions in the number of deaths and injuries, as well as reduced property damage.

3.3.11. Wildfire

Description

A wildfire is an unplanned fire that burns in a natural area such as a forest, grassland, or prairie. The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from the destructive effects of wildfires. Each year, an average of about 3,059 wildfires burn more than 49,280 acres of forest and grassland in Missouri. Most of the fires occur during the spring season, normally between February 15 and May 10. The length and severity of burning periods largely depend on the weather conditions.

Vulnerability	Extent/Range of Intensity
	Wildfire events can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating. A wildfire has the potential to kill people, livestock, fish and wildlife. The severity in Missouri is considered low to moderate.

Probability	Severity	Location
100%, 3,059 wildfire events per year average	Low to Moderate	Statewide

State Vulnerability Overview

With over 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area. Although the National Fire Incident Reporting System does capture data on wildfires, it was determined that the Department of Conservation historical wildfire data was the best resource. The Department of Conservation data has more individual events recorded per county. Therefore, this data appeared to be more comprehensive. From the Department of Conservation wildfire data from 1993 to 2021, it was determined that the average annual number of wildfires in Missouri was 3,059 burning an average annual 49,280 acres.

Changing Future Conditions Considerations

Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and changing future conditions are also likely to increase the damage from insects and diseases. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover about one-third of the state, dominated by oak and hickory trees. As the climate changes, the abundance of pines in Missouri's forests is likely to increase, while the population of hickory trees is likely to decrease.

Risk Summary/Problem Statement

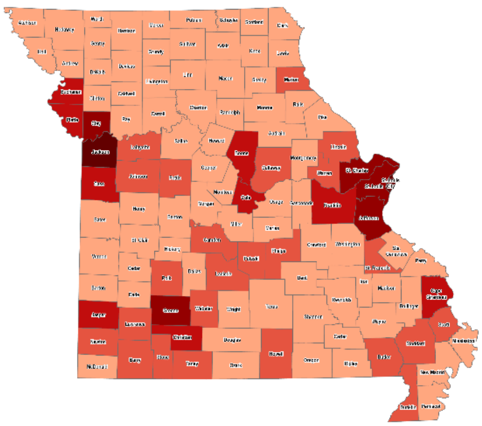
With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. Wildfires may also be a cascading or secondary impact of another hazard such as earthquakes or tornadoes, as a result of damaged gas lines. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural fires.

3.3.12. Civil Disorder Overview

Description

Civil disorder is a term that generally refers to groups of people purposely choosing not to observe a law, regulation, or rule, usually in order to bring attention to a cause, concern, or agenda. In Missouri, state statutes define civil disorder as “any public disturbance involving acts of violence by assemblages of three or more persons, which cause an immediate danger of or results in damage or injury to the property or person of any other individual.”

Vulnerability



Extent/Range of Intensity

The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. The rules of constitutional law set stringent limits on how police officers can behave toward the people they try to arrest. Restraint also plays a crucial part in avoiding any action that “fans the flames.” This is particularly important provided that recent protests in Missouri have centered around police brutality. Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. As a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive. Counties particularly vulnerable are, St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin.

Changing Future Conditions Considerations

As a human-caused hazard, any changes in climate would not have a direct impact on civil disorder. Far more relevant, though, could be the implications of future climate change as a cause for civil disorder. Climate change impact forecasts include increasingly extreme weather patterns that exacerbate issues of drought, flooding, severe weather and other weather hazards globally that could affect whole ecosystems. Incidents of civil disobedience could be a secondary result related to societal unrest as a result of other climate-impacted hazards.

Risk Summary/Problem Statement

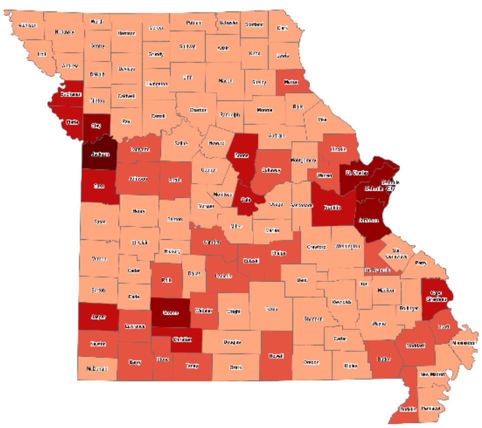
Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

3.3.13. Cyber Disruption

Description

Cyber disruption is an interruption or disruption of the normal operations, use and/or function of a cybernetic system. Disruptions can typically fall into two very general categories; un-intentional disruption and intentional disruption. Un-intentional disruptions are the more common type of disruption as they usually occur when a portion of the system fails. Intentional disruption is typically a directed 'attack' on a cybernetic system to achieve an intended goal, which is usually malicious in intent.

Vulnerability



Extent/Range of Intensity

The State of Missouri categorizes the severity of a cyber disruption ranging from low to high depending upon the system disrupted and the intention of the attacker. Some systems have redundant capabilities or are not critical to daily operations. As such the severity of a disruption to that system is low. However, there are other systems that are integral to operations, contain sensitive information, or provide access/control to critical systems. A disruption to those systems would have a severe impact on the state.

Probability	Severity	Location
100%	Low to High	Statewide

State Vulnerability Overview

Cyber disruptions have the potential to undermine the confidence that people have in their own security when dealing with any number of cyber systems. Intentional events would also succeed in building doubt in their government's ability to protect them from harm. The potential for a major cyber disruption, through intentional attacks, is the scenario that is more likely to occur, based on currently available information. Attacks of that variety are minimal, though increasing in frequency as the threat evolves. Attackers are likely to have either very specific targets, or desire wide-spread publicity from the attacks that would lead towards the targeting of popular, iconic, or critical systems.

Changing Future Conditions Considerations

Cyber Disruption is considered a human-caused/technological hazard and is not impacted by changes in weather patterns/climate.

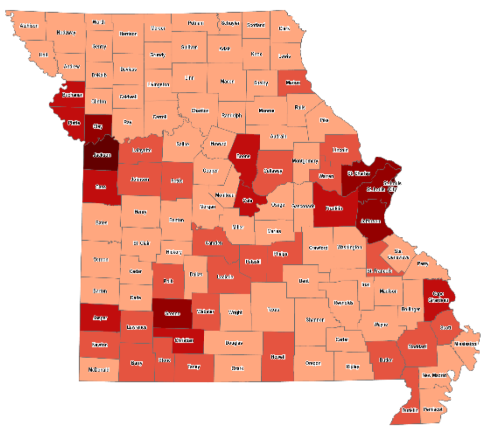
Risk Summary/Problem Statement

Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

3.3.14. Environmental Health Emergencies

Description

Environmental health is a branch of public health that focuses on the relationships between people and their environment. Environmental health is a key part of any comprehensive public health system. It focuses on topics that include chemical and other environmental exposures in air, water, soil, and food, and the impacts that various pollutants have on the environment and thus the health of people and communities. Environmental health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident.

Vulnerability	Extent/Range of Intensity
	Two scales for measuring the intensity of an environmental health emergency are the US Air Quality Index and Missouri's Water Quality Standards. The U.S. Air Quality Index (AQI) is the EPA's index for reporting air quality. Missouri's Water Quality Standards (WQS) are defined in the Code of State Regulations (10 CSR 20-7.031). The objective of WQS is protecting uses through applying criteria. Water quality criteria are expressed as concentrations, loads or narrative statements.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Environmental incidents involving air and water pollution would likely impact a more localized area; however, long-term effects on the environment in the impacted area could linger for many years. Although Missouri has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people.

Changing Future Conditions Considerations

Higher temperatures lead to an increase in allergens and harmful air pollutants. For instance, longer warm seasons can mean longer pollen seasons – which can increase allergic sensitizations and asthma episodes and diminish productive work and school days. The frequency of heavy precipitation events has already increased for the nation as a whole and is projected to increase in all U.S. regions. In addition to the immediate health hazards associated with extreme precipitation events when flooding occurs, other hazards can often appear once a storm has passed.

Risk Summary/Problem Statement

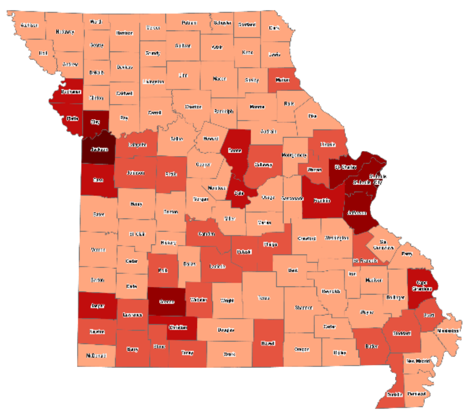
Using population and major transportation corridors as key indicators, the data suggests that counties at most risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

3.3.15. Hazardous Materials Release (Fixed Facility and Transportation Accidents)

Description

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The category of hazardous materials release includes incidents involving substances such as toxic chemicals, fuels, nuclear wastes and/or products, and other radiological and biological or chemical agents. For the purposes of this analysis, only accidental or incidental releases of hazardous materials from two different kinds of incidents are addressed: fixed facility and transportation-related accidents.

Vulnerability



Extent/Range of Intensity

The entire State of Missouri is susceptible to this type of hazard. However, the magnitude of a hazardous materials release incident will vary in every case depending on the amount spilled or released, type of chemical, method of release, location of release, time of day, and weather conditions. Close coordination between the Missouri Department of Natural Resources, the U.S. Environmental Protection Agency (EPA), the local jurisdiction, and the spiller (responsible party) will be required to minimize the potential impacts to public health and the environment.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

The entire State of Missouri is susceptible to this type of hazard, depending on a number of factors such as the type of chemical, amount released/spilled, method of release, location of release, time of day, and weather conditions. This hazard could have a significant impact on the public health, the environment, private property, and the economy. The impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. If contamination occurs, the spiller is responsible for the cleanup actions and will work closely with the Missouri Department of Natural Resources, EPA, and the local jurisdiction to ensure that cleanup is done safely and in accordance with federal and state laws.

Changing Future Conditions Considerations

Accidental or incidental releases of hazardous materials are non-natural incidents and therefore, there are no implications for impacts from climate change. However, there is growing evidence that hazardous material releases triggered by natural hazards can pose significant risks. In these incidences, the impact of climate change is of a secondary nature. It may exacerbate the natural hazard event by triggering release of hazardous materials.

Risk Summary/Problem Statement

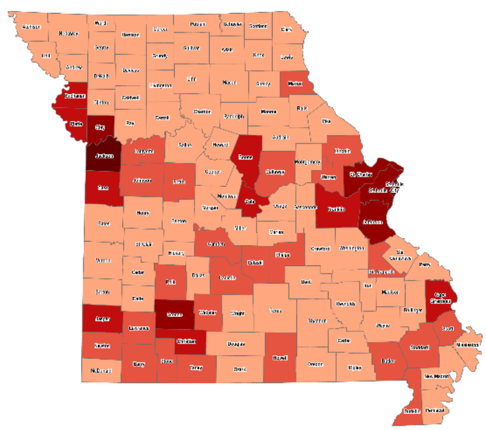
Using the County of Tier II Facilities and the major transportation corridors for the State as key indicators, the counties at most risk for Hazardous Materials Release are St. Louis City, Jackson, Greene, St. Charles, St. Louis County, Boone, Clay, Jefferson, Jasper, and Franklin. Mitigation strategies and limited resources would best be allocated in these counties.

3.3.16. Mass Transportation

Description

Mass transportation is defined as the means, or system, that transfers large groups of individuals from one place to another. Mass transportation accidents include public airlines, railroad passenger cars, metro rail travel, tour buses, city bus lines, school buses, riverboat casinos, and other means of public transportation.

Vulnerability



Extent/Range of Intensity

There is no uniform extent rating for a mass transportation incident, as different modes of transportation have unique characteristics. Depending on the parameters of the incident, it is reasonable to assume that a large-scale mass transportation incident involving a train derailment or a plane crash could cause hundreds of fatalities, hundreds of injuries, millions in property damage and a potentially long-term loss of service.

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

Mass transportation systems have strict plans and protocols in place to ensure the safety and security of their passengers. Even with these protocols in place, a major accident could occur at any time. Mass transportation systems can also serve as attractive targets for terrorism, with high numbers of people congregated in small spaces and the potential for disruption in daily lives.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard. The exception would be accidents caused by precipitation or other severe weather, such as high winds.

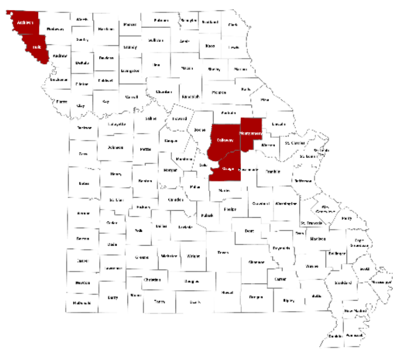
Risk Summary/Problem Statement

Using the major transportation corridors for the State and population as key indicators, the counties at most risk for Mass Transportation incidents are Boone, Buchanan, Clay, Franklin, Greene, Jackson, Jasper Jefferson, St. Charles, and St. Louis County, as well as the City of St. Louis. Mitigation strategies and limited resources would best be allocated in these counties.

3.3.17. Nuclear Power Plants

Description

There are presently four fixed nuclear facilities or reactors that, under extreme circumstances and conditions, could pose a threat to citizens of Missouri. These four reactors fall into two categories: research reactors and commercial nuclear power reactors. The first category, research reactors, represents a hazard only to personnel or others on-site at the facility. For the second category, commercial nuclear power reactors, a worst-case scenario involving a significant release of radioactive material could force the evacuation of the general population within a 10-mile radius of the facility. A release of this magnitude could also contaminate food and water sources within a 50-mile radius.

Vulnerability	Extent/Range of Intensity
	The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Probability	Severity	Location
Less than 1%	Low to High	Atchison, Callaway, Holt, Montgomery, and Osage Counties

State Vulnerability Overview

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the State can range in severity from insignificant to a high degree of radioactive contamination within the two to 10-mile radius surrounding the facility. The most crucial concerns during a severe incident are safe evacuation and controlled access to the areas affected by a release of radioactive materials; these processes are managed under the State of Missouri Nuclear Power Plant Action Plan. In the aftermath of a radiological incident, the main concerns include the extent of property needing to be decontaminated, contaminated food sources, and the time required to reach acceptable exposure rates and to allow the safe reentry of the public. Due to their safe operation records, fixed nuclear facilities have not historically represented a high risk to the State.

Changing Future Conditions Considerations

Generally, an incident involving a nuclear reactor would not have an impact on climate change, nor would climate change have a measurable effect on the impacts of a nuclear power plant incident. An influx of population or development in the areas around the plants would create added risk.

Risk Summary/Problem Statement

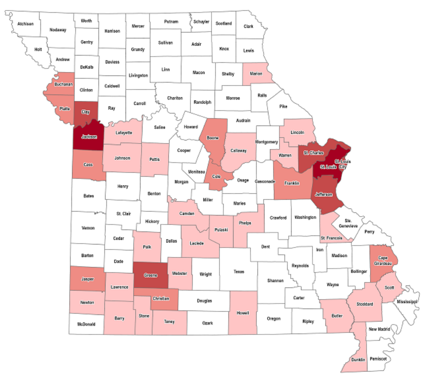
Using the Counties within a 10-mile radius of nuclear plants as the key indicator, the counties as most risk from fallout are Callaway, Montgomery and Atchison. Mitigation strategies and limited resources would best be expended in these counties first.

3.3.18. Public Health Emergencies

Description

Public health emergencies can take many forms—disease epidemics, large-scale incidents of food or water contamination, or extended periods without adequate water and sewer services. There can also be harmful exposure to chemical, radiological, or biological agents, and largescale infestations of disease-carrying insects or rodents. Public health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people.

Vulnerability



Extent/Range of Intensity

Public health emergencies can be worldwide or localized in scope and magnitude. All of Missouri is at risk to public health emergencies. When on an epidemic scale, diseases can lead to high infection rates in the population causing isolation, quarantine, and potential mass fatalities. An especially severe influenza or coronavirus pandemic or other major disease outbreak can lead to high levels of illness, death, social disruption, and economic loss.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Buildings, infrastructure, and critical facilities are not vulnerable to this hazard – rather it affects only persons susceptible to the illness. Other lasting impacts and potential losses are largely economic and are dependent on the type, extent, and duration of the illness. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

Changing Future Conditions Considerations

Based on climate predictions, communities must contend with the human health impacts related to the increased prevalence of infectious diseases, heat waves, and changes in air and water quality. Heat stress is expected to increase as climate change brings hotter summer temperatures and more humidity. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Higher temperatures and wetter conditions tend to increase mosquito and tick activity, leading to an increased risk of zoonotic diseases. More frequent and extreme storm events can exacerbate the challenges communities face with sheltering, evacuation, and access to medical care and other resources during and after an extreme weather event.

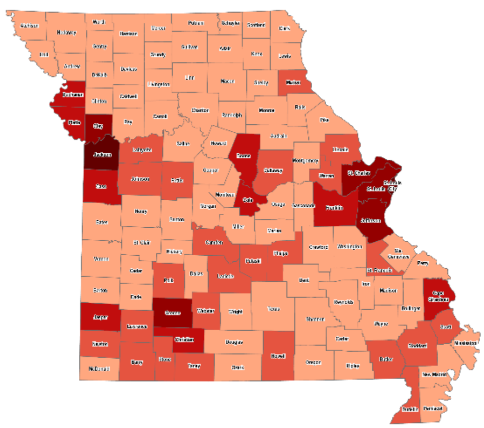
Risk Summary/Problem Statement

Preparing for, responding to, and recovering from pandemic influenza, and other outbreaks will require a strategy with many similarities, be they naturally occurring or resulting from terrorist action. By its very nature, a pandemic, once started, will not be stopped until it has run its course. DHSS has emergency response plans in place, internally, and as part of the State response through the Missouri State Emergency Operations Plan (SEOP) that have been tried, tested and exercised for all aspects of response and recovery, including those mentioned above relating to disease surveillance, investigation and control.

3.3.19. Special Events

Description

Special events present a unique set of challenges and security issues, including vulnerability to both man-made and natural hazards. Special events can include sporting events, concerts, political events, and events with religious significance, and can be handled at the local, state or federal level, depending on the size and scope of the event itself. Security for some special events can be handled with local- and state-level coordination, while some events rise to a level of national significance requiring a National Special Security Event designation and federal agency input and direction. Special events usually occur in larger cities, though this isn't always the case. When planning for special events, security officials should account for vulnerability to both natural and man-made hazards.

Vulnerability	Extent/Range of Intensity
	The Special Events Assessment Rating (SEAR) is the single federal interagency resource used for assessing and categorizing domestic events that do not rise to the level of a National Security Special Event (NSSE). Using a risk-based approach to weigh vulnerabilities and consequences against threats, the SEWG develops the SEAR levels based primarily on event information submitted by S/L/T/T officials in the annual Data Call.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Significant special events where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government are potential targets for attacks such as terrorist attacks and civil disorder. Regardless of the purpose for the event, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from just about any of the hazards detailed in this risk assessment could have compounded and devastating impacts. It is not possible to calculate a specific vulnerability across Missouri. However, because of the desire for publicity following terrorist-type attacks at special event venues, it is more likely that counties with greater population densities would be the target of such attacks.

Changing Future Conditions Considerations

As Missouri continues to attract special events with local, state and/or national level awareness, the potential for vulnerabilities increases. Proper planning for large scale events plays a significant role in mitigating potential impacts. As weather hazards potentially strengthen due to a changing climate, special events will see increased vulnerability due to intensified weather incidents.

Risk Summary/Problem Statement

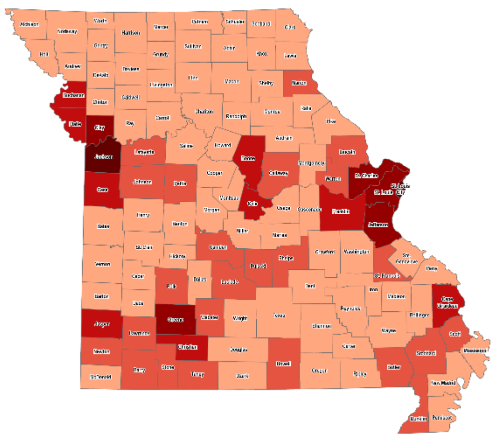
Using the major transportation corridors for the State and population as key indicators, the counties at most risk are Boone, Buchanan, Clay, Franklin, Greene, Jackson, Jasper Jefferson, St. Charles, and St. Louis County; as well as the City of St. Louis. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

3.3.20. Terrorism

Description

Terrorism, as defined by the Federal Bureau of Investigation (FBI), is “the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives.” The effects of terrorism can vary significantly, including loss of life, injuries to people and properties, and disruptions in services (e.g., water supplies, public transportation, and communications).

Vulnerability



Extent/Range of Intensity

Extent is reliant on the type of attack and other parameters. Terrorism is usually attempted to kill or injure persons, destroy property or impact critical functions, and affect public confidence and instill fear.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Terrorist acts could easily undermine the confidence that people have in their own security and in their government’s ability to protect them from harm. Because bombs can be made so easily, the threat of a bomb should not be taken lightly. The threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the persons making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community. A strategic nuclear, biological, or chemical attack on the United States could have the most devastating and far-reaching consequences. The use of these weapons against the United States is unlikely. Unfortunately, however, as long as such weapons exist, there is always a chance that they could be used.

Changing Future Conditions Considerations

Changing future conditions in terms of climate and weather patterns are not expected to have a direct impact on the probability or severity of potential terrorism events. However, there are extreme environmental groups that may resort to forms of terrorism in their protests.

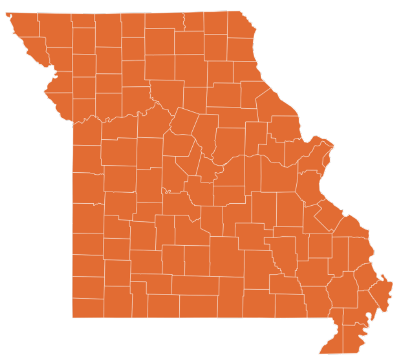
Risk Summary/Problem Statement

Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

3.3.21 Structural and Urban Fires

Description

Structural fires are a major problem that can affect any area of the State. As defined by the National Fire Protection Agency (NFPA), a structure fire is defined as “any fire inside, on, under, or touching a structure.” Because buildings exist anywhere people live and work, fires can occur at anytime and anyplace throughout the State. Minor urban fires can be expected often in Missouri. Major fires occur several times a year, particularly in dense, urban areas with aging building stock. Fires impact many aspects of society in terms of economic, social, and other indirect costs.

Vulnerability	Extent/Range of Intensity
	The impact of a fire to a single-story building in a small community may be as great as that of a larger fire to a multistory building in a large city. A variety of factors will determine the extent of damage to the individual structure. Damage can range from minor to substantial with damages far exceeding the value of the structure. Factors that impact fire extent include structure type, age, density of development, presence of flammable substances, and more.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Structural and urban fires are a daily occurrence throughout the State. According to the U.S Fire Administration, approximately 2.2 fatalities per 1,000 fires occur annually in Missouri, as well as numerous injuries affecting the lives of the victims, their families, and many others—especially those involved in fire and medical services. Unlike other disasters, structural fires are often insidious and despicable due to the prevalence of arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services, or the costs of supporting the criminal justice system. According to this vulnerability analysis Greene, Jackson, and St. Louis counties, and the City of St. Louis have a high vulnerability to structural and urban fires.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard. The wildland-urban interface (WUI) is commonly described as the zone where structures and other human development meet and intermingle with undeveloped wildland or vegetative fuels. A warmer, drier climate create favorable conditions for wildfires which may increase the potential for structural fires within the WUI zones.

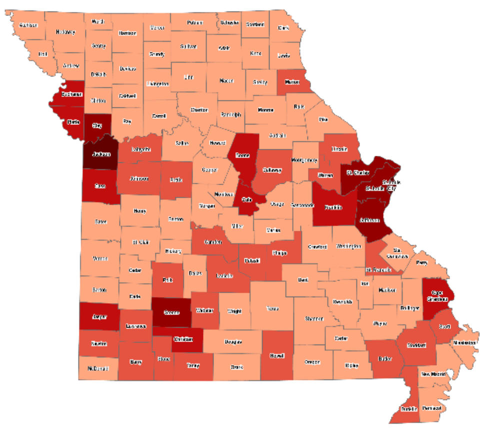
Risk Summary/Problem Statement

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. The greatest risk of interaction by fires with other hazards may involve damaging earthquakes. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural and urban fires.

3.3.22. Utilities (Interruptions and System Failures)

Description

Utility Interruptions and failures may involve electrical power, internet/telecommunications systems, natural gas, and public water and wastewater systems. These systems or combinations of these utility systems exist virtually throughout the State. Many utilities are localized and serve only one community, while other utilities serve a regional area. Disruption of any of these services could result from many of the natural or human-caused / technological hazards described in this plan.

Vulnerability	Extent/Range of Intensity
	In many cases, utility interruptions are small, isolated events that are within the capabilities of the local utility to address. Due to long-range planning, regulation, and diligence of the utility operators, major interruptions resulting in a high degree of severity are few and far between. In some instances, utility outages and interruptions can impact a larger area and be for a prolonged period. Utility outages can also often be a cascading impact of a primary hazard such as flooding, severe thunderstorm, severe winter weather, and cyber disruptions.

Probability	Severity	Location
100%	Low	Statewide

State Vulnerability Overview

Utilities and infrastructure are vulnerable to damage from many natural hazards. Public health and safety and potential impacts on the economy are primary concerns with this hazard. Power and telephone lines are the most vulnerable infrastructure asset; but water supply, wastewater facilities and communications towers are also vulnerable. Typically, the events that cause the most damages are flood, lightning, winter storm, tornado, and wind storm. The electrical grid is vulnerable in periods of extreme heat when air conditioning use peaks. Underground utilities can also be damaged by expansive soils, erosion, earthquake and intentional or unintentional human actions.

Changing Future Conditions Considerations

Deteriorating infrastructure is a current nationwide problem that is likely to be exacerbated by changing future conditions. For example, existing stormwater systems were designed based on past conditions that are now changing; many systems may quickly become inadequate if storms continue to become more frequent and/or intense.

Risk Summary/Problem Statement

Severe weather causes more frequent local, and occasionally widespread, utility outages, however, manmade incidents, accidental or intentional, could significantly impact utility service. The earthquake threat to statewide and multi-state utilities is the greatest concern to the integrity and operability of Missouri's utilities. Utility companies are generally well prepared to deal with day-to-day outages. Planning, regulation, mitigation, and mutual aid are all just a few tools available to reduce, speed recovery from, and prevent utility interruptions and failures.

1 Prerequisites

Hazard mitigation has become an increasingly important component of disaster recovery since 1988 when the Disaster Relief Act of 1974, Public Law 93-288, was amended by Public Law 100-707, the Robert T. Stafford Disaster Relief and Emergency Assistance Act. Greater emphasis was placed on hazard mitigation and pre-disaster mitigation (Section 203) with the enactment of another amendment, the Disaster Mitigation Act of 2000. This Missouri State Hazard Mitigation Plan Update is a direct result of the latter amendment to the Stafford Act.

The Disaster Mitigation Act (DMA) of 2000 enacted the following provisions relative to mitigation planning:

Standard State Mitigation Plans (201.4 of the Rule): To receive federal mitigation funds, states must develop and submit for approval to FEMA a Standard Hazard Mitigation Plan that includes details of the State's natural hazards risks, vulnerabilities, and mitigation goals, objectives, and priorities. States with an approved Standard Hazard Mitigation Plan are eligible for Hazard Mitigation Grant Program (HMGP) funding based on 15 percent for disaster assistance not more than $2 billion, 10 percent for disaster assistance of more than $2 billion and not more than $10 billion, and 7.5 percent for disaster assistance more than $10 billion and not more than $35.3 billion of the total estimated eligible Stafford Act disaster assistance as a result of a presidential major disaster declaration.

Enhanced State Mitigation Plans (201.5 of the Rule): States that have an approved Enhanced State Mitigation Plan at the time of a disaster declaration will qualify to receive HMGP funds based on up to 20 percent of the total estimated eligible Stafford Act disaster assistance. This document is the scheduled 2023 update to Missouri's standard and enhanced state hazard mitigation plan, which was initially approved by FEMA in 2004 and previously updated in 2007, 2010, 2013, and 2018.

Section 404 Hazard Mitigation Grant Program (HMGP) allows the federal government to contribute up to 75 percent of the cost of cost-effective hazard mitigation measures that substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster. Such mitigation measures shall be identified following the evaluation of natural hazards under Section 322 of the Disaster

Mitigation Act. Section 404 funds may be used for a variety of eligible projects that may or may not be related to the disaster and, if the State allows, in counties that were not in the declared disaster area.

In addition to the HMGP, other funding mechanisms are available in Missouri with an approved standard state plan. These programs listed below are further described in Section 4 of this plan.

- FEMA Hazard Mitigation Assistance Grants
    - HMGP Post Fire Grant
    - Flood Mitigation Assistance (FMA) Program
    - Building Resilient Infrastructure and Communities (BRIC) Program
- FEMA Public Assistance
    - Categories C-G (repairs to damaged infrastructure, publicly owned buildings)
- Fire Mitigation Assistance Grants (FMAG)
- High Hazard Potential Dam (HHPD) Grant Program

1.1. Plan Adoption

Requirement for Update §201.4(c)(6): The Plan must be formally adopted by the State prior to submittal to [FEMA] for final review and approval.

The Missouri State Hazard Mitigation Plan is the result of the systematic evaluation of the nature and extent of vulnerability to the effects of all hazards (natural, human-caused/technological, and other) present in Missouri and includes the actions needed to minimize future vulnerability to those hazards. It sets forth the policies, procedures, and philosophies that will be used to establish and implement hazard mitigation activities within the State. Effective and consistent implementation of this plan is crucial to the hazard mitigation program and the State's efforts to reduce or eliminate the threat of future disasters. This plan, initially adopted May 12, 2004, along with subsequent adopted updates, incorporates all changes associated with the implementation of the federal/state hazard mitigation program, including the applicable sections of the DMA 2000 and is in compliance with the following standards for accreditation outlined in the 2019 Emergency Management Standard developed by the Emergency Management Accreditation Program (EMAP).

- Hazard Identification, Risk Assessment and Consequence Analysis
- Hazard Mitigation

Overall administration of the hazard mitigation program is the responsibility of the Missouri State Emergency Management Agency (SEMA) Recovery Division, Mitigation Management Section. The Mitigation Management Section will review the plan annually or as needed if hazard mitigation regulations or guidelines change. The plan will be formally updated, submitted to FEMA Region VII for approval, and adopted every five years, or as required, such as following a presidential disaster declaration if the State's priorities change.

The FEMA State Mitigation Plan Policy Guide, effective April 2022, provided additional guidance on plan adoption requirements. This revised guidance requirement states "the state must provide documentation of formal adoption by the highest elected official or designee prior to the final review and approval by FEMA". The intent of this revised guidance requirement is to provide statewide recognition and demonstration of risk reduction as a statewide priority.

1.2. Compliance with Federal and State Laws and Regulations

Requirement §201.4(c)(7): The plan must include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).

General Compliance Assurance Statement

This plan is prepared to comply with the requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (as amended by the DMA); all pertinent presidential directives associated with the U.S. Department of Homeland Security and FEMA; all aspects of 44 CFR pertaining to hazard mitigation planning and grants pertaining to the mitigation of adverse effects of disasters (natural, manmade, and other); interim final rules and final rules pertaining to hazard mitigation planning and grants, as described above; all planning criteria issued by FEMA; and all Office of Management and Budget circulars and other federal government documents, guidelines, and rules.

The State of Missouri agrees to comply with all federal statutes and regulations in effect with respect to mitigation grants it receives, in compliance with 2 CFR parts 200 and 3002. As stated in Section 1.1 Plan Adoption, the plan will be updated every five years or as required and amendments will be made as necessary to address changes in federal or state statutes, regulations, and policies. Such amendments will be submitted to FEMA for approval. Additional information about how the plan will be reviewed and updated is in Section 6.1.1

SEMA intends to comply with all administrative requirements outlined in 2 CFR parts 200 and 3002 in their entirety and to monitor all Sub-recipients supported activities to ensure compliance with 2 CFR parts 200 and 3002 in their entirety.

SEMA also requires all Sub-recipients receiving $750,000 or more in federal assistance to have an audit conducted in accordance with the Single Audit Act under 44 CFR 14, Administration of Grants: Audits of State and Local Governments. Such reports by an independent certified public accountant will be maintained by SEMA. All general audit requirements in 44 CFR 14 will be adhered to by SEMA as well as Sub-recipients receiving FEMA hazard mitigation grant awards.

Authorities

The Missouri State Hazard Mitigation Plan is an important component of state-level programs for management of disasters and their impacts. As such, the strategy relies on the authorities given to the state agencies and their programs herein incorporated for implementation of its strategies and assignments. Further, the plan is intended to be consistent with and supportive of the policies, plans, and implementation procedures that govern mitigation-related state agency programs. In the event of any inconsistency, state agency policies and programs supersede the provisions of the plan. The State's mitigation strategy relies upon and is intended to be consistent with the following specific state and federal authorities as well as EMAP mitigation standards:

Statutes

State

- Constitution of the State of Missouri, as amended
- Chapter 44, Emergency Management, Revised Statutes of Missouri, as amended
- Chapter 160.451-160.457, Schools—General Provisions, Earthquake Emergency Procedure, Revised Statutes of Missouri, 2003
- Chapter 256, Geology, Water Resources, and Geodetic Survey, Interstate Earthquake Emergency Compact and Geologic Hazard Assessment, Revised Statutes of Missouri, 2003
- Chapter 319, General Safety Requirements, Pipelines, Seismic Building Ordinances, Revised Statutes of Missouri, 2003

Federal*

- Public Law 106-390, Disaster Mitigation Act of 2000 (Amendment to Robert T. Stafford Disaster Relief and Emergency Assistance Act
- The National Security Act of 1947
- Public Law 84-99 (33 USC 701n) for flood emergencies
- Public Law 85-256, Price-Anderson Act
- Public Law 89-665 (16 USC 470 et seq.), National Historic Preservation Act
- Public Law 90-448, National Flood Insurance Act of 1968 (42 USC 4001 et seq.)
- Public Law 91-646, Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (42 U.S.C. 4601 et seq.)
- Public Law 93-288, as amended by Public Law 100-707, The Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 6121 et seq.)
- Public Law 93-234, Flood Disaster Protection Act of 1973
- Public Law 95-124, as amended by Public Laws 96-472 and 99-105, Earthquake Hazards Reduction Act of 1977 (42 USC 7701 and 7704)
- Public Law 96-295, The Nuclear Regulatory Commission Appropriations Authorization Act
- Public Law 96-510, Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Section 104(i),(42 USC 9604(i))
- Public Law 99-499, Superfund Amendments and Reauthorization Act of 1986
- Public Law 101-615, Hazardous Materials Transportation Uniform Safety Act
- Public Law 101-549, Clean Air Amendments of 1990
- Public Law 107-296, Homeland Security Act of 2002

*As amended where applicable

Administrative Rules

Federal

- 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards
- 2 CFR Part 3002, Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards
- 44 CFR Part 9, Floodplain Management and Protection of Wetlands
- 44 CFR Part 10, Environmental Considerations
- 44 CFR Part 13 (The Common Rule), Uniform Administrative Requirements for Grants and Cooperative Agreements

- 44 CFR Part 14, Audits of State and Local Governments
- 44 CFR Parts 59-76, National Flood Insurance Program and related programs
- 44 CFR Part 60, Subpart A, including § 60.3 Flood plain management criteria for flood-prone areas
- 44 CFR Part 77, Flood Mitigation Grants
- 44 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards, as adopted by the U.S. Department of Homeland Security (DHS) at 2 CFR Part 3002.
- 44 CFR Part 201, Mitigation Planning
- 44 CFR Part 204, including § 204.51 (d)(2) [Fire Management Assistance Grant (FMAG) mitigation plan requirement]
- 44 CFR Part 206, Subpart N – Hazard Mitigation Grant Program (HMGP)
- 49 CFR Part 24, Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally Assisted Programs

Executive Orders

State

- 82-19, Provisions for the necessary and appropriate state coordination and participation with the Federal Insurance Administration under the National Flood Insurance Act of 1968
- 93-40, Establishes the Task Force on Flood Plain Management
- 94-25, Established the Disaster Recovery Partnership with human services disaster response
- 97-09, Authorizes SEMA to issue floodplain development permits for any state owned or leased development in a special flood hazard area
- 03-23, Reaffirms the endeavors of the Disaster Recovery Partnership and ascribes to it the additional functions of a state citizen council
- 05-20, Establishes the Missouri Homeland Security Advisory Council to review and evaluate current state and local homeland security plans
- 06-10, Creates the Citizen Corps to help coordinate volunteer and individual or family preparedness activities in any emergency situation
- 06-41, Creates the Interdepartmental Coordination Council for Water Quality
- 09-25, Creates and establishes the Governor’s Faith-Based and Community Service Partnership for Disaster Recovery

Federal

- Executive Order 11988, Floodplain Management
- Executive Order 11990, Protection of Wetlands
- Executive Order 12656, Assignment of Emergency Preparedness Responsibilities
- Executive Order 12148, Federal Emergency Management
- Executive Order 12699, Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
- Executive Order 13985 on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government

- Executive Order 14008 on Tackling the Climate Crisis at Home and Abroad, Justice40
- Executive Order 14030 on Climate-Related Financial Risk
- Homeland Security Presidential Directive 5, Management of Domestic Incidents
- Homeland Security Presidential Directive 8, National Preparedness
- Homeland Security Presidential Directive 21, Critical Infrastructure Security and Resilience

Other

Emergency Management Accreditation Program, 2019

- 4.1 Hazard Identification, Risk Assessment and Consequence Analysis
- 4.2 Hazard Mitigation

2 Planning Process

2.1. Documentation of the Planning Process

Requirement §201.4(c)(1): [The State plan must include] a description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.

The process established for this planning effort is based on the Disaster Mitigation Act of 2000 (DMA 2000) planning and update requirements and FEMA's associated State Mitigation Plan Review Guide, effective March 2016 (FP 302-094-2). In addition, FEMA's new State Mitigation Planning Policy Guide (effective April 2023) and Key Topics Bulletin: Planning Process (released in July 2016) were consulted to ensure renewed focus on an effective planning process for the State Hazard Mitigation Plan Update. The primary steps in the planning process included:

1) Updates to the identification and profiles of the types of hazards (natural, human-caused/technological, and other) that affect the State
2) Updates to the assessment of present and future risk and vulnerability of Missouri residents and critical assets to these hazards
3) Updates to the assessment of capabilities of locals, state agencies, federal agencies, and stakeholder groups to mitigate hazards
4) Updates and prioritization of the key issues that should be addressed by mitigation efforts
5) Updates to the goals, objectives, and mitigation action to address key issues to reduce the State's vulnerability to present and future hazards

2.1.1. Evolution of the State Hazard Mitigation Plan

The Missouri State Hazard Mitigation Plan in its current form has evolved over the last 20 years. In 1994, in response to the 1993 Midwest Flood Disaster, and in accordance with the planning regulations in place at the time (Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988), the first Missouri Hazard Mitigation Plan was developed. Under Section 409, states were required to prepare and update state hazard mitigation plans within six months of a Presidential Disaster Declaration as a condition for receiving federal disaster assistance.

With the passage of the Disaster Mitigation Act of 2000, the Stafford Act was amended, and Section 322 mitigation planning requirements replaced (HMC) the older requirements in Section 409. The first State Hazard Mitigation Plan prepared in accordance with the Disaster Mitigation Act of 2000 was the 2004 Missouri State Hazard Mitigation Plan. This plan was updated in 2007, 2010, and 2013, 2018, and 2023 (this plan update).

A State Hazard Mitigation Planning Team (SHMPT) was formed to develop the 2004 State plan and continued for the 2007 and 2010 plan updates. This team evolved to include several federal agencies and additional expanded stakeholder agencies and became known as the State Risk Management Team (SRMT) for the 2013 plan update. Since 2013, the SRMT has met twice each year to discuss issues relevant to risk management and mitigation as well as coordinate across partner agencies to leverage programs and support. For the 2018 and 2023 plan update, the SRMT was utilized as the advisory body to assist in its development.

Missouri employs a continuous improvement process to ensure that the State's mitigation planning and program efforts are effective. Missouri's planning and program successes to date are demonstrated throughout this document.

2.1.2. 2023 Plan Update Process

In March 2022, Missouri initiated the planning process to update the Missouri State Hazard Mitigation Plan. The Missouri State Emergency Management Agency (SEMA) took the lead role, under direction of the Mitigation Management Section, with the State Hazard Mitigation Officer as the planning lead. For assistance in development of the plan update, SEMA contracted with Wood Environment and Infrastructure Solutions (Wood E&IS), Inc.

Wood E&IS's role included the following 16 tasks:

- **Task 1:** Facilitate and document the process used to develop the plan update, including:
  - Assist in identifying representatives and reconvening the SRMT as defined by the DMA 2000, April 2023 State Mitigation Planning Policy Guide, and the July 2016 State Mitigation Planning Key Topics Bulletins: Planning Process
  - Ensure compliance with the DMA 2000 requirements as established by federal regulation and the April 2023 State Mitigation Planning Policy Guide
  - Facilitate the entire planning process
  - Identify the data requirements that SRMT participants should provide and conduct research and documentation necessary to augment that data
  - Documentation of how the plan was prepared, the schedule or timeframe, specific milestones and activities, stakeholders that involved in the process, and how other agencies participated.
- **Task 2:** Complete the update to the Risk Assessment for each hazard, including:
  - Incorporation of improvements to the State Risk Assessment Vulnerability Analyses as a result of availability of more current data and process improvements
- **Task 3:** Preparing an Executive Summary to incorporate a full summary text/table of all counties with their respective vulnerability to each hazard type.
- **Task 4:** Incorporation of the impacts and considerations for changing future conditions statewide and in each hazard assessment
- **Task 5:** Integration of local level risk assessments through an assessment of local plans to extract data for inclusion in the State assessments
- **Task 6:** Improving vulnerability analyses of state-owned/operated facilities based on the improved State Risk Assessment
- **Task 7:** Provide a summary of the changes in development that have occurred or are projected to occur in hazard prone areas based on the state and local risk assessments.
- **Task 8:** Update the State Mitigation Strategy, goals, actions, funding sources, and progress on existing actions.
- **Task 9:** Update State Mitigation Capabilities to include updated descriptions of existing state pre- and post-disaster hazard management policies, programs, and capabilities to mitigation hazards in the state
- **Task 10:** Review and update the process to monitor, evaluate, and update the plan including the agency responsible for and the schedule for monitoring, evaluating, and updating the plan. This task also describes the system for tracking the implementation of mitigation activities and projects

identified in the mitigation strategy, as well as, a system for reviewing progress on achieving the goals of the mitigation strategy, including criteria and process for evaluating progress.

- **Task 11:** Preparation of the Enhanced Plan including:
  - Comprehensive description of integrated planning in the State of Missouri
  - Demonstrate the State of Missouri successfully implements programs or projects that reduce exposure to hazards or other mechanisms that show the state has exceeded the requirements of the standard plan.
  - Demonstrate the State of Missouri effectively manages the HMGP as well as other mitigation grant programs
- Develop supplemental Enhanced Plan Elements in coordination with the SRMT to include:
  - **Task 12:** With the recent Disaster Declaration DR-4490-MO for COVID-19 Pandemic, this task will focus on review of the 2018 vulnerability assessment for the Public Health Emergency Hazard and development of mitigation strategies in coordination with the multiple agencies and stakeholders of the ongoing pandemic.
  - **Task 13:** For FY2020, FEMA has made federal funds available through the new Building Resilient Infrastructures and Communities (BRIC) grant program to states, local communities, tribes and territories (SLTTs) for pre-disaster mitigation activities. This task will incorporate and analyze the effectiveness of SEMA's integration of the BRIC program into statewide mitigation efforts.
  - **Task 14:** A study of the Public Assistance Program's 406 Mitigation program to determine additional opportunities to utilize this Post-Disaster Recovery program more effectively in future disasters.
  - **Task 15:** Updates to the Application for Accessible Risk Assessment Data. The purpose of this Application is to streamline access for local planners to the data obtained and/or created throughout the State Plan process.
- **Task 16:** Produce the draft and final plan documents and coordinate with the FEMA Region VII plan reviewers.

For the 2023 plan update, seven planning meetings were held with the SRMT:

- At the March 2022 **Kickoff Meeting**, the SRMT discussed the purpose and requirements of the state plan update, the project scope of work and schedule, and reviewed the existing mitigation actions. During the course of the plan update, five additional planning meetings were held after the kickoff meeting. Highlights include:
- **Meeting #2** - An update on development trends across the State was presented along with the proposed approaches for the State Risk Assessment Hazard Vulnerability Analyses. The hazard profiles for each of the severe weather hazards and human-caused hazards was presented including previous occurrences, the extent, and a description of the risk analysis method. Additionally, an overview of the State Capability Assessment was provided.
- **Meeting #3** – The results of the Risk Assessment for the GIS-based hazards (including flooding, levee failure, dam failure, earthquake, and land subsidence) were presented to the SRMT, as well as the public health emergencies hazard and the integration of post-disaster recovery (406) mitigation.
- **Meeting #4** – The final data needs of the State Risk Assessment Hazard Vulnerability Analyses were identified and requested of the SRMT. Additionally, the format of the one-page hazard

summary/introduction pages was presented, along with the roll-up of local mitigation planning, changes for the 2023 plan to address EMAP requirements, and the schedule for review of the plan document.

- **Meeting #5** – The flood risk assessment and hazard profile was presented to the SRMT along with the Missouri Hazard Mitigation Viewer, the Mitigation Action Prioritization process, and update on review of the plan document.
- **Meeting #6** – An overview of the draft 2023 State Hazard Plan document was presented to the SRMT along with the incorporation review comments from the SRMT.
- **Meeting #7** – Follow-up to Meeting #6, reviewing the draft plan document with the SRMT and addressing review comments.

Table 2.1 provides additional details on the meetings held during the plan update process. Agendas, sign-in sheets, meeting handouts and other documentation have been compiled in a planning reference file that is available from SEMA upon request.

Table 2.1. 2023 State Hazard Mitigation Plan Update Planning Meetings

Meeting	Date	Topics Discussed
Kickoff Meeting	03/23/2022	• Introductions • Overview of Mitigation • Mitigation in Missouri • Role of the State Hazard Mitigation Team • 2023 Update Process—Overview of 16 Main Tasks • Review of Current Mitigation Actions • Plan Update Timeline
Meeting #2	04/27/2022	• Introductions • Plan Update Tasks / Meeting Schedule • State Development Trends • Risk Assessment Methodologies • Risk Assessment Results for Severe Weather Hazards • Risk Assessment Results for Human Caused Hazards • State Capability Assessment • Next Steps • Adjourn
Meeting #3	05/25/2022	• Introductions • Plan Update Tasks / Meeting Schedule • Risk Assessment Results for GIS-based Hazards • Public Health Emergencies Hazard • Integration of Mitigation into Post-Disaster Recovery (406 Mitigation) • Next Steps • Adjourn
Meeting #4	06/29/2022	• Introductions • Plan Update Tasks / Meeting Schedule • HIRA overview of summary page for each hazard • Final HIRA data needs • Discussion of recent Mass Transportation Incident • Local Plan Roll-up • EMAP Changes for 2023 Update • Next Steps • Adjourn

Meeting	Date	Topics Discussed
Meeting #5	07/27/2022	• Introductions • Using Hazus for Mitigation Planning • Flood Risk Assessment Update • Missouri Hazard Mitigation Viewer • Final Data Needs - Update • Mitigation Action Prioritization Process • Schedule for Reviews of Plan Document – Update! • Document Review Process • Next Steps • Adjourn
Meeting #6	09/28/2022	• Introductions • Document Review Process • Mitigation Action Prioritization • Next Steps • Adjourn
Meeting #7	10/26/2022	• Introductions • Document Review Process, Walk-Through Draft Sections • Next Steps • Adjourn

For the 2023 plan update, there were continued effort to integrate as much available geospatial or geographical information systems (GIS) data as possible and to integrate many of emerging worldwide technologies for data display. This is a theme running throughout the plan update. GIS staff for Wood E&IS assessed the available GIS data statewide through multiple sources which included the Missouri Spatial Data Information Service (MSDIS), the official GIS website for the State maintained by the University of Missouri. GIS was also obtained from various SRMT member agencies in a collaborative partnership with SEMA. In some instances, data available from SRMT member agencies was shared in tabular format and converted to GIS data. A summary of sources for GIS data include:

- MSDIS located at http://msdis.missouri.edu which included datasets for landslide potential, liquefaction potential, landslide potential, inventory of landslide occurrences, higher education institutions, air quality monitoring sites, 303d listed impaired streams and lakes, inventory of mines, caves, and sinkholes
- U. S. Census located at TIGER/Line Shapefiles (census.gov) provided census data as well as county boundaries
- USACE SRMT members provided Federal Dams locations and inundation areas as well the national levee data from National Levee Database (army.mil)
- EPA HSIP Freedom data from https://hifld-geoplatform.opendata.arcgis.com/ which included facility information on hazardous materials, medical facilities, fire stations, National Bridge Inventory, National Levee Inventory and schools
- NOAA climate data from the NCEI at https://gis.ncdc.noaa.gov/maps/ncei
- FEMA's Hazus software GIS data was exported to be used in other risk assessments for consistency including earthquake data
- FEMA's NFIP national floodplain data was obtained from https://msc.fema.gov and additionally provided the Repetitive Loss and Severe Repetitive Loss data for the State
- USGS located at Land Use Land Cover Modeling - Data & Tools | U.S. Geological Survey (usgs.gov) provided land use data
- FEMA Region VII proved the Regional version of the National Levee Database

- CUSEC provided additional earthquake GIS data
- Missouri Association of Councils of Government Regional Council- RPCs - MO Association of Councils of Government (macog.org)
- MODNR SRMT members provided wildland fire data
- SEMA provided Disaster Region data, NFIP participating communities and a large inventory of data from the floodplain mapping update program
- MODHE proved Higher Education facility data
- MDC proved facility locations
- MODOT provided a statewide bridge inventory and state transportation layer

It is through this data availability matrix that a large wealth of information was able to be integrated into the plan in a meaningful and comprehensive manner.

2.1.3. Plan Review and Update Summary

During the 2023 State Hazard Mitigation Plan Update process, each section of the 2018 plan was reviewed and updated, as appropriate. At each step of the update process, the March 2016 State Plan Review Guide, the April 2023 State Mitigation Planning Policy Guide, and applicable key topic bulletins that were released prior to completion of the plan were consulted to ensure conformance with the most recent guidance and planning aides. The Emergency Management Accreditation Program (EMAP) standards for mitigation were also considered to ensure continued accreditation of Missouri's Emergency Management Program. This plan update includes improved organization and formatting of the plan's content where possible.

Table 2.2 provides a summary of the updates made to each section of the plan. Additional detailed documentation on updates made is provided at the beginning of each plan section.

Table 2.2. Summary of Updates for 2023 State Hazard Mitigation Plan

Plan Section	Summary of Updates
Entire Plan	• This document is a user-interfaced, Web-based interactive plan. It has been formatted with active embedded hyperlinks throughout which will direct the user to: o Internal document locations; o External SEMA websites; and o External third-party websites where additional information can be found.
Executive Summary	• An Executive Summary was added to present an overview of all counties with their respective vulnerability to each hazard type.
1 Introduction	• Updated language to describe purpose and requirements of the Missouri State Hazard Mitigation Plan update process.
2 Planning Process	• Described planning process for 2023 update, coordination among agencies, and integration with other planning efforts. • A cross-reference table for EMAP mitigation standards was added to address the 2019 Emergency Management Standard.
3.0 Risk Assessment	• Section 3.1 through 3.6 updated for the 2023 plan. • Several tables of county level information were moved to Appendix A, Risk Assessment Data, to reduce the volume of the mitigation plan document. • EMAP consequence analysis tables have been removed from the individual hazard profiles and are now presented in Appendix C along with EMAP requirements for risk and vulnerability assessments.

Plan Section	Summary of Updates
3.1 Exposure Analysis of Assets at Risk and State Development Trends	• Described changes in growth and development and examined these changes in the context of hazard-prone areas and how the changes affect loss estimates and vulnerability.
3.2 Hazard Identification	• This section is divided into 3.2.1 Natural Hazards, 3.2.2 Human-Caused/Technological Hazards, and 3.2.3 Disaster Declarations. • Former CBRNE Attack hazard was integrated with Terrorism. Terrorism is the focus as an intentional, criminal, malicious acts. A CBRNE attack is one method of implementing a terrorist act. • Former Public Health Emergencies/Environmental Issues hazard was separated into two distinct hazard profiles. • Updated declarations table and figure as well as tables providing IA and PA costs by disaster.
3.3 Hazard Profiles and State Risk Assessment	• The hazard profiles developed for this 2023 Plan Update serve as the bases for hazard profile needs in other State Plans, promoting continued integration. • Each hazard was profiled to include information on description/location, extent, previous occurrences, probability of future hazard events, and changing future conditions. • Proposed approaches for State Risk Assessment Hazard Vulnerability Analyses were presented and discussed at SRMT Meeting #2. • Each hazard was analyzed for vulnerability and potential loss estimation. Additionally, changes in development for jurisdictions in hazard prone areas and a risk summary was provided for each hazard. • A summary of the vulnerability analysis/loss estimation updates are presented in Table 3.6. • EMAP risk assessment, vulnerability assessment, and consequence analysis is included in Appendix C.
3.4 Integration of Local Plans: Vulnerability and Loss Estimates	• Reviewed risk assessments from 114 local plans to summarize how local governments conducted the risk assessments, utilizing data from either the 2018 state plan or outside sources. • Summarized problem statements from all local plans to identify potential mitigation actions for the state to address.
3.5 State Owned or Operated Facilities: Vulnerability and Loss Estimates	• Major improvements were made to available facility and bridge data resulting in an improved dataset from which to base the vulnerability assessments and loss estimations. Table 3.102 presents a summary of the updated state facility inventories. • For the 2023 State Plan Update, the following facilities were inventoried in GIS format and included in the analyses: • Vulnerability analysis and loss estimates were provided for all the profiled hazards where data was available. New data allowed for the analysis of vulnerability to sinkholes, wildfire, and hazardous materials fixed facility incidents. Table 3.105 presents a summary of the updated vulnerability and loss estimations by county.
3.6 References	• Updated reference information utilized in the hazard identification, profiles and risk assessments.
4.0 Mitigation Strategy	• Updated Section 4.0 based on the results of the updated risk assessment, data from the local plans, completed mitigation actions, and implementation obstacles and opportunities since the previously approved plan.
4.1 Hazard Mitigation Goals and Objectives	• Goals and objectives from the 2018 plan were reviewed during SRMT Meeting #1. The SRMT concluded that the goals and objectives continued to be representative of the state's mitigation strategy.

Plan Section	Summary of Updates
4.2 Mitigation Actions	• Existing mitigation actions discussed at SRMT Meeting #1. • New mitigation actions discussed at each SRMT Meeting. • Mitigation action categories M1-M11 remain applicable. • Progress of actions since 2018 documented and mitigation actions updated and/or revised. • Prioritization of mitigation actions conducted through online survey.
4.3 Repetitive Flood Loss Strategy	• Described the State's current Repetitive Flood Loss Strategy with updated repetitive loss and severe repetitive loss data by community along with new section on Targeted Actions.
4.4 Funding Sources	• Identified funding sources used since previously approved plan. • Appendix D provides a list of funding sources updated for this 2023 State Plan update.
4.5 State Capability Assessment	• Evaluated state laws, regulations, policies, and programs related to hazard mitigation, as well as, to development hazard prone areas. • Updated the state capabilities, both pre- and post-disaster, and how these capabilities have changed since the previously approved plan. • Discussed state funding capabilities for hazard mitigation projects and how the state has used FEMA mitigation programs and funding sources. • Discussed obstacles and challenges and changes since the previously approved plan.
4.6 Local Capability Assessment	• Performed local capability assessment through review of: o Planning Capabilities; o Building Codes, Policies, and Ordinances; o Mitigation-related Programs/Partnerships; o Specific Studies; o Staffing Positions; and o Potential Funding Sources • Analyzed effectiveness of local capabilities through a survey developed to obtain input from local governments, state, federal, and stakeholder agencies. A summary of the results is provided.
5.0 Coordination of Local Mitigation Planning	• Reviewed process for and progress in coordinating local mitigation planning. • Updated information on the status of local plan completion.
5.1 Local Funding and Technical Assistance	• Described how the State provided funding, technical assistance, and training to local governments since the previously approved plan, including development of new training materials and planning resources. • Summarized current status of counties with completed and approved local plans, those in process, and those without plans.
5.2 Local Plan Integration	• Described how local risk assessments, goals and objectives, mitigation actions, and capabilities were integrated into the updated state plan. • Assessed the challenges and success of this 2023 integration.
5.3 Prioritizing Local Assistance	• Reviewed criteria for prioritizing communities and local jurisdictions that would receive planning and project grants and determined existing criteria including the coordination with mitigation actions identified through the RiskMAP process and entered into FEMA Region VII's Regional Action Tracker (RAT).
6.0–6.2 Plan Maintenance Process	• Reviewed procedures for evaluating and updating the plan and determined that no changes were required. • Updated monitoring information from the most current Administrative Plan.

Plan Section	Summary of Updates
7.0–7.6 Enhanced Plan	• Reviewed and revised sections based on FEMA's guidance for enhanced plan updates. • Continued integration of enhanced plan information with other sections of the plan. • Researched and developed a comprehensive multi-year plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post-disaster response and recovery operations. • With the recent Disaster Declaration DR-4490-MO for COVID-19 Pandemic, review of the 2018 vulnerability assessment for the Public Health Emergency Hazard and development of mitigation strategies in coordination with the multiple agencies and stakeholders of the ongoing pandemic. • Performed study of the Public Assistance Program's 406 Mitigation program to determine additional opportunities to utilize this Post-Disaster Recovery program more effectively in future disasters. • Updated the web-application for accessible risk assessment data.

2.2. Coordination among Agencies

Requirement §201.4(b): The [State] mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, and interested groups.

As the agency designated by the Missouri Governor to coordinate statewide emergency preparedness, response, recovery, and hazard mitigation activities, SEMA acted as the coordinator of the SRMT during the planning process. SEMA recognizes the importance of coordinating with local, state, and federal agencies, as well as other interested groups involved in hazard mitigation planning. This coordination is necessary to enhance data collection, mitigation strategy development, plan implementation, and overall investment in Missouri's mitigation program.

For this plan update, the role of the SRMT included the following:

- Attend Planning Meetings
- Assist with Data Collection
- Serve as Advisory Group for State Risk Assessment Methods
- Report on Agency Mitigation Capabilities
- Leverage Funding / Programs to Maximize Benefits
- Provide Input to Mitigation Strategy/Actions
- Review Drafts

The SRMT consists of a broad range of stakeholders from various sectors, agencies, and organizations. The key sectors represented on the SRMT include the following:

- Emergency Management
- Economic Development
- Land Use and Development
- Housing
- Health and Social Services
- Infrastructure

- Natural and Cultural Resources

Table 2.3 provides the entities invited to participate on the SRMT for the plan update process as well as those represented at the planning meetings for the 2023 update of the State Hazard Mitigation Plan. The SRMT members also provided data and technical information to update and strengthen the risk assessments; status updates on existing mitigation actions and input/prioritization on new mitigation actions, and reviewed and provided comments on the draft plan document. Additionally, SEMA's Mitigation Management Section and the Community Development Block Grant group have resumed doing quarterly meetings to discuss coordination and on-going partnership, with the goal of strengthening the State's ability to provide cohesive, collaborative assistance post and pre-disaster. Meetings will incorporate discussions of new disasters, funding opportunities, and possible project collaboration.

Table 2.3. SRMT Involvement in the 2023 Plan Update Process

Agency/Division	Sector	Participated in 2023 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
Missouri State Agencies										
State Emergency Management Agency (SEMA)	Emergency Management	X	X	X	X	X	X	X	X	X
Department of Agriculture (MDA)	Land Use and Development	X				X				X
Department of Conservation (MDC)	Natural and Cultural Resources	X			X	X				X
Department of Corrections (MOC)	Health and Social Services									
Department of Economic Development (DED)[1]	Economic Development; Housing	X								X
Department of Elementary and Secondary Education (DESE)	Health and Social Services	X								X
Department of Health and Senior Services (DHSS)	Health and Social Services	X						X		X
Department of Higher Education (DHE)	Health and Social Services	X								X
Department of Insurance, Financial Institutions, and Professional Registration (DIFP)	Economic Development	X								X
Department of Labor and Industrial Relations (DOLIR)	Economic Development									
Department of Mental Health (DMH)	Health and Social Services	X	X							X
Department of Natural Resources (MoDNR), Dam Safety	Natural and Cultural Resources	X	X	X	X	X	X	X	X	X
MoDNR, Missouri Geological Survey (MGS)	Natural and Cultural Resources	X								X
MoDNR, Energy Center	Natural and Cultural Resources	X								X
MoDNR, Environmental Services Program	Natural and Cultural Resources	X								X
Department of Public Safety (DPS), Division of Fire Safety (DFS)	Emergency Management	X						X	X	X
DPS, State Highway Patrol (MSHP)	Emergency Management									
DPS, State Water Patrol (MSWP)	Emergency Management									
Public Service Commission (PSC)	Economic Development	X								X
Department of Social Services (DSS)	Health and Social Services	X	X	X	X	X		X		X
Department of Transportation (MoDOT)	Infrastructure	X			X		X			X
Division of Tourism	Economic Development									
Office of Administration (OA)	Economic Development	X	X	X	X		X	X	X	X
National Guard (MONG)	Emergency Management	X	X							X
National Air Guard (MOANG)	Emergency Management									

Agency/Division	Sector	Participated in 2023 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
Boonslick Regional Planning Commission	Economic Development; Land Use and Development	X								X
Bootheel Regional Planning and Economic Development Commission	Economic Development; Land Use and Development	X								X
East-West Gateway Coordinating Council	Economic Development; Land Use and Development	X								X
Green Hills Regional Planning Commission	Economic Development; Land Use and Development	X								X
Harry S Truman Coordinating Council	Economic Development; Land Use and Development	X								X
Kaysinger Basin Regional Planning Commission	Economic Development; Land Use and Development	X								X
Lake of the Ozarks Council of Local Governments	Economic Development; Land Use and Development	X								X
Mark Twain Regional Council of Governments	Economic Development; Land Use and Development	X								X
Meramec Regional Planning Commission	Economic Development; Land Use and Development	X								X
Mid-America Regional Council	Economic Development; Land Use and Development	X								X
Mid-Missouri Regional Planning Commission	Economic Development; Land Use and Development	X								X
Mo-Kan Regional Council	Economic Development; Land Use and Development	X								X
Northeast Missouri Regional Planning Commission	Economic Development; Land Use and Development	X								X
Northwest Missouri Regional Council of Governments	Economic Development; Land Use and Development	X								X
Ozark Foothills Regional Planning Commission	Economic Development; Land Use and Development	X							X	X
Pioneer Trails Regional Planning Commission	Economic Development; Land Use and Development	X								X
South Central Ozark Council of Governments	Economic Development; Land Use and Development	X								X
Southeast Missouri Regional Planning and Economic Development Commission	Economic Development; Land Use and Development	X								X
Southwest Missouri Council of Governments	Economic Development; Land Use and Development	X								X
Federal Stakeholders										
FEMA Region VII	Emergency Management	X	X	X	X	X	X	X	X	X
National Oceanic and Atmospheric Administration National Weather Service	Natural and Cultural Resources	X	X				X			X

Agency/Division	Sector	Participated in 2023 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
U.S. Army Corps of Engineers (USACE) Kansas City	Infrastructure	X	X	X	X	X	X		X	X
USACE Little Rock District	Infrastructure	X								X
USACE St Louis District	Infrastructure	X	X	X	X	X	X		X	X
USACE Memphis District	Infrastructure	X								X
USACE Rock Island District	Infrastructure	X								X
USACE Omaha District	Infrastructure	X								X
USACE Tulsa District	Infrastructure	X								X
U.S. Department of Agriculture (USDA), Forest Service, Mark Twain National Forest	Land Use and Development	X								X
USDA, Natural Resources Conservation Service	Natural and Cultural Resources	X								X
USDA, Rural Development Agency	Land Use and Development	X								X
U.S. Department of Commerce, Economic Development Administration	Economic Development	X								X
U.S. Department of Homeland Security	Emergency Management	X								X
U.S. Department of Housing & Urban Development	Housing	X								X
U.S. Department of Transportation	Infrastructure	X								X
U.S. Environmental Protection Agency	Natural and Cultural Resources	X								X
U.S. Geological Services (USGS)	Natural and Cultural Resources	X	X		X					X
U.S. Small Business Transportation	Infrastructure									
Private Stakeholders										
Adventist Community Services	Health and Social Services									
AmeriCorps	Health and Social Services									
American Red Cross	Health and Social Services									
Association of Missouri Electric Cooperative (AMEC)	Infrastructure	X								X
Callaway Nuclear Power Plant (AUE)	Infrastructure	X								X
Cooper Plant Nebraska Public Power District (NPPD)-Entergy Support	Infrastructure	X								X
Kansas City Power and Light (KCPL)	Infrastructure	X	X							
Missouri Baptist Convention	Health and Social Services									
Missouri Community Service Commission	Health and Social Services	X	X							
Missouri Floodplain and Stormwater Managers Association (MSFMA)	Land Use and Development	X								X

Agency/Division	Sector	Participated in 2023 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
Missouri Hospital Association	Health and Social Services									
Missouri Public Health Association	Health and Social Services	X								X
Missouri Water / Wastewater Agency Response Network (MoWARN)	Emergency Management						X			
The Salvation Army	Health and Social Services									

[1] Follow-up coordination with DED included discussion on the mitigation planning efforts, CDBG and mitigation funding, and opportunities for disadvantaged communities to access mitigation funds.

2.3. Integration with Other Planning Efforts

Requirement §201.4(b): The [State mitigation planning process] should be integrated to the extent possible with other ongoing State Planning efforts as well as other FEMA mitigation programs and initiatives.

The Missouri State Hazard Mitigation Plan Update identifies Missouri's hazards, risks, vulnerabilities, goals, objectives, priorities, and strategies for mitigation. This plan is the governing document that SEMA uses to direct and focus mitigation efforts. Through the establishment and continued coordination of the SRMT, this plan and the process to update it have also served as a mechanism to guide mitigation goals and objectives across multiple stakeholder entities, including federal partners, other state agencies, local entities, as well as contributing private-sector stakeholders.

Inclusion of key stakeholder entities has been an ongoing process that has helped inform partner agencies and organizations about the importance of mitigation. This education process has resulted in the ability to leverage other stakeholder programs and planning initiatives to advance mitigation opportunities and concepts.

2.3.1. Integration with Other Ongoing State Planning Efforts

The State of Missouri is fully committed to an effective and comprehensive mitigation program. Missouri is somewhat unique in that the FEMA Hazard Mitigation Assistance (HMA) grant programs, Earthquake Program, and mitigation planning are all the direct responsibility of SEMA. For these programs to achieve their full potential as well as to leverage available funding and resources of other mitigation-related programs available in Missouri, integration with other planning efforts is crucial. Some examples as to how the State mitigation planning process is integrated with other ongoing State planning efforts are provided below:

- Mitigation is considered, where possible by Missouri statutes, in the earthquake plans of the Departments of Transportation; Insurance, Financial Institutions, and Professional Registration; Corrections; Natural Resources; Education; the Office of Administration; the Public Service Commission; Missouri Seismic Safety Commission; Missouri Emergency Response Commission; and others.
- The Department of Transportation considers mitigation, especially floodplain management and open-space issues, in their transportation plans.
- The Department of Conservation has partnered with SEMA in developing streambank stabilization planning to help mitigate flooding problems in communities such as Piedmont, Missouri.
- The vulnerability analysis of state-owned facilities continued to be expanded in this 2023 State Plan Update and the results have been provided to the Office of Administration, Department of Higher Education, Department of Transportation, and Missouri Department of Conservation. For those facilities for which GIS data was provided, the State agencies have been provided with the results indicating specific facilities potentially at risk to inundation from failure of state-regulated dams, flooding from a 100-year flood event, and levee failure; location relative to sinkholes and potential wildfires; and damage from an earthquake event with a 2% probability of exceedance in 50 years. Results were provided in both GIS (geodatabase) and Excel spreadsheet formats. Provision of this data is provided specifically so that those State-agencies are made aware of potential risks to determine if mitigation opportunities are necessary and/or feasible. Section 3.5 provides additional details.

During the 2023 State Plan update, the SRMT reviewed the mitigation-related programs and initiatives, mitigation-related outreach and partnerships, mitigation-related plans and reports, and mitigation-related funding sources of other State agencies. The purpose of this review was to identify changes, updates, and/or additions since the 2018 Mitigation Plan to incorporate relevant data and capabilities into the mitigation plan and to better understand areas where mutual responsibilities and policies could be leveraged. Identified mitigation-related capabilities of other State agencies participating on the SRMT are provided in Section 4.5.1.

SEMA also works to implement the components of this plan by being a part of the SRMT and working with state agencies that participate on the Missouri Seismic Safety Commission, state agencies that help develop mitigation measures associated with Public Assistance projects, and state educational institutions that participate in the mitigation program.

In addition to working with FEMA in all aspects of hazard mitigation projects and plans, SEMA has worked with multiple federal mitigation partners to integrate mitigation into projects and plans. Examples include:

- The Natural Resources Conservation Service (NRCS) and U.S. Army Corps of Engineers provided input and advice on several mitigation initiatives in the State regarding retention/detention basins. The successful combination of SEMA buyouts and NRCS retention basins in the City of Neosho, a former Project Impact Community, is an excellent example of the NRCS' support.
- An NRCS feasibility study led the City of Piedmont to develop several flood buyout programs to mitigate flooding over time and Project Impact Disaster Resistant Community status. Piedmont also worked with the Missouri Department of Conservation to reduce flooding through creek cleanup and streambank stabilization activities and plans. In addition, Piedmont and the City of Maryville worked with the Economic Development Agency, using SEMA's hazard mitigation planning process, to develop communitywide business plans for disaster survivability. The City of Hannibal (another former Project Impact community) followed Piedmont's creek cleanup lead and conducted similar activities.

SEMA has also supported efforts to reduce damages from severe winter storms, such as the project undertaken by the City of Independence to bury electric service lines to homes that were damaged by the severe Ice Storm of 2002. Similarly, SEMA worked with the City of Bolivar (also a former Project Impact community) helping the city procure and issue NOAA weather warning radios to local schools, nursing homes, day care centers, and college dormitories.

Approximately 681 Missouri communities participate in the National Flood Insurance Program (NFIP), an increase of 10 jurisdictions since the 2018 Mitigation Plan. Participation in the Community Rating System (CRS) has also increased from 10 to 15 jurisdictions. The SEMA Recovery Division, Floodplain Management Section conducts workshops each year promoting the NFIP to nonparticipating communities. Additional workshops are conducted to promote the CRS. These workshops have been instrumental in increasing the number of communities participating in both programs.

SEMA supports the NWS StormReady program and its many mitigation measures in Missouri. Participation in the program continues to increase since the 2018 Mitigation Plan. Currently Missouri has 35 counties (7 new counties; one dropped county); 46 communities (four new; nine dropped); six universities, three commercial sites, and 21 supporters that are recognized as StormReady.

The Missouri Department of Economic Development's Community Development Block Grant Program (CDBG) has complemented the SEMA buyout program in removing homes and businesses from the flood hazard areas throughout the State. The SEMA program has concentrated primarily on family residences, while the CDBG program has included businesses and some residences. Together, these programs have made a significant impact on the overall vulnerability of individuals to flooding as well as reducing the costs of future flooding.

Other partners and projects include the following:

- The U.S. Army Corps of Engineers has worked with SEMA on several levee projects, the Silver Jackets program, and requests for channelization projects.
- The Missouri Department of Conservation has worked with SEMA on endangered species and fish and wildlife management issues associated with flood buyouts and water management and conservation questions.
- The Missouri Department of Agriculture works with SEMA on agriculture and drought issues and planning, including ways to mitigate damage.
- The Missouri Department of Insurance, Financial Institutions, and Professional Registration supports SEMA in promoting flood and earthquake insurance, preparedness, response, and mitigation issues and plans.
- The Missouri Department of Natural Resources has worked with SEMA on flood buyouts, hazardous material planning, earthquake mitigation, and dam safety plans and issues.
- The Missouri Department of Transportation, the U.S. Department of Transportation, and the Federal Highway Administration have worked with SEMA on flood buyouts, open-space restriction issues, and earthquake planning and bridge retrofits.
- In addition to the state and federal transportation agencies, the U.S. Geological Survey; Central U.S. Earthquake Consortium; MoDNR; Missouri Department of Insurance, Financial Institutions, and Professional Registration; Missouri Seismic Safety Commission; Missouri Structural Assessment and Visual Evaluation (SAVE) Coalition (members include the American Council of Engineering Companies/Missouri, American Institute of Architects/Missouri, American Society of Civil Engineers, Missouri Society of Professional Engineers, Structural Engineers Association of Kansas and Missouri, University of Missouri–Rolla School of Civil Engineering and Natural Hazards Mitigation Institute, Saint Louis University Earthquake Center, Washington University, Southern Illinois University–Edwardsville, University of Memphis Center for Earthquake Research and Information, and Earthquake Engineering Research Institute New Madrid Chapter) work with SEMA on earthquake mitigation, including retrofits, public education, soil mapping, and seismic studies.
- SEMA's statewide volunteer coordinator has worked for years to educate local, state, and national voluntary organizations through the Disaster Recovery Partnership, Community Organizations Active in Disaster, and the Missouri Voluntary Organizations Active in disasters about the importance of mitigation.
- SEMA's staff served on the State American Red Cross mitigation committee.

The general information in this plan is intended for use by interested local governments, universities, businesses, and private associations, in addition to state and federal departments and agencies.

2.3.2. Integration with other FEMA Mitigation Programs and Initiatives

Mitigation is woven throughout SEMA's execution of FEMA's Risk Mapping Assessment and Planning (Risk MAP) program. SEMA has developed, and regularly updates, a five-year Combined Strategic and COMS Business Plan which emphasizes its comprehensive and integrated approach to Risk MAP that includes floodplain mapping, risk assessment and mitigation planning unified by risk communication that meets or exceeds FEMA goals and program intent. SEMA has fully committed to engaging communities, stakeholders and project team members throughout the life of the Risk MAP projects through active Community Outreach and Mitigation Strategies (COMS) activities to build risk awareness and understanding at the local level, increase communities' ability to communicate risk at the local level and support local efforts to reduce natural hazard risk within the community through mitigation actions. Examples of these are:

- Workshops on how to use DFIRM products and Risk MAP products are presented annually.
- Quarterly communications on project status are sent to community officials.
- Phone calls with local officials are fielded weekly on a full range of questions regarding floodplain management.
- When communities are not able to attend meetings, SEMA routinely delivers data personally to community officials to ensure it's received, and questions are answered.
- An outreach website is maintained which stores the Modeling Methods maps, the proposed floodplains, meeting documentation and the ability to comment on the proposed data.
- Resilience on Command (ROC) projects have been developed by modeling engineers who find areas where mitigation potential exists and provides "what if" scenario information showing how a particular area could be mitigated by an action such as upsizing a culver that is impeding the flow of water and causing flooding. These projects provide the communities with information for what impacts could be expected by the mitigation measure, a rough estimate of what the measure could cost and applicable grant sources to assist in funding the project. These ROC projects follow the Flood Study Review meetings during the Data Development portion of the Risk MAP project life cycle.

To measure the success of the Risk MAP program, Risk MAP Action Measures have been developed and are tracked in accordance with FEMA Region VII guidance. SEMA works with communities to understand their needs and educate and engage them to take mitigation actions to minimize their flood risk. As per Region VII guidance, SEMA gathers all the information that is necessary to include in the Mitigation Action Tracker. While most mitigation activity takes place at the local level and is measured at the community level in watersheds where Risk MAP is deployed, SEMA identifies which communities can potentially advance actions utilizing Risk MAP products. SEMA provides literature, how-to-guides and best practices in mitigation actions to promote mitigation action advancement in those identified communities.

2.3.3. Integration with EMAP Standards

During the 2023 plan update, the SRMT considered the State's overall mitigation planning process in the context of the 2019 Emergency Management Accreditation Program's (EMAP) mitigation standards. EMAP is a voluntary assessment and accreditation process for state emergency management programs. Accreditation is granted only following a rigorous peer review of all aspects of a state's emergency management program. **Table 2.4** presents the EMAP mitigation standards and corresponding reference in this 2023 State Plan update.

Table 2.4. EMAP Mitigation Standards Addressed in the 2023 State Plan

2019 EMAP Standard		2023 State Plan
4.1 Hazard Identification, Risk Assessment and Consequence Analysis		
4.1.1	The Emergency Management Program identifies the natural and human-caused hazards that potentially impact the jurisdiction using multiple sources. The Emergency Management Program assesses the risk and vulnerability of people, property, the environment, and its own operations from these hazards.	Section 3.2 Hazard Identification Appendix C, Section C.1 presents the risk and vulnerability assessment definitions, risk assessment methodology, and vulnerability assessment methodology. Appendix C, Section C.2 presents the risk and vulnerability assessment results for each hazard.
4.1.2	The Emergency Management Program conducts a consequence analysis for the hazards identified in Standard 4.1.1 to consider the impact on the following: public; responders; continuity of operations including continued delivery of services; property, facilities, and infrastructure; environment; economic condition of the jurisdiction; and public confidence in the jurisdiction's governance.	Appendix C, Section C.1 presents the consequence analysis definitions and methodology. Appendix C, Section C.2 presents the consequence analysis results for each hazard.
4.1.3	The Emergency Management Program has a method and schedule for evaluation, maintenance, and revision of its Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis identified in Standard 4.1.1 and the Consequence Analysis identified in Standard 4.1.2., which includes a method and schedule for evaluation and revision.	Sections 2.1.2 and 2.1.3 describe the State Plan Update process including the hazard information in Section 3. Additionally, SEMA updates its Threat and Hazard Identification and Risk Assessment (THIRA) annually in accordance with the Comprehensive Preparedness Guide 201.
4.2 Hazard Mitigation		
4.2.1	The Emergency Management Program has a plan to implement mitigation projects and sets priorities based upon loss reduction.	Section 4.2.2 Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions
4.2.1 (1)	The plan … is based on the natural and human-caused hazards identified in Standard 4.1.1 and the risk and consequences of those hazards.	Table 4.5 presents how mitigation actions relate to the different hazards, as well as, the associated probability and severity.
4.2.1 (2)	The plan … is developed through formal planning processes involving Emergency Management Program stakeholders; and	Section 2.1.2 and 2.2 describe the planning process and coordination/ participation of stakeholders.
4.2.1 (3)	The plan … establishes short- and long-term strategies, actions, goals, and objectives	Section 4.2, Hazard Mitigation Goals and Objectives Section 4.2, Mitigation Actions
4.2.2	The Emergency Management Program documents project ranking based upon the greatest opportunity for loss reduction and documents how specific mitigation actions contribute to overall risk reduction.	Section 4.2.2, Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions
4.2.3	The Emergency Management Program has a process to monitor overall progress of the mitigation activities and documents completed initiatives and their resulting reduction or limitation of hazard impact on the jurisdiction.	Section 4.2.4, Review and Progress of Mitigation Actions
4.2.4 The Emergency Management Program, consistent with the scope of the mitigation program, does the following:		
4.2.4 (1)	… identifies ongoing mitigation opportunities and tracks repetitive loss;	Section 4.3, Severe Repetitive Loss Strategy
4.2.4 (2)	… provides technical assistance in implementing mitigation codes and ordinances; and	Section 5.1.5, Technical Assistance
4.2.4 (3)	… participates in applicable jurisdictional and multi-jurisdictional mitigation efforts.	Section 2.3, Integration with Other Planning Efforts

2019 EMAP Standard		2023 State Plan
4.2.5	The Emergency Management Program has a maintenance process for the plan identified in Standard 4.2.1, which includes a method and schedule for evaluation and revision.	Section 6, Plan Maintenance

2.3.4. Challenges in Planning Integration

Traditionally, the State of Missouri has had great success in integrating with other state planning efforts as well as FEMA mitigation programs and initiatives. Challenges in integration that exist continue to relate to lack of staff, meeting schedule conflicts, and lack of time to focus on other plans and programs in addition to daily work duties. One challenge the State was able to overcome was a result of the COVID-pandemic and the increased use of virtual meetings. With virtual meeting in place, staff members do not struggle as much with the lack of travel funds for meetings. More information on integration with other planning efforts can be found in Section 4.2 Mitigation Actions, Section 4.5 State Capability Assessment, Section 5.2 Local Plan Integration, and Section 7.1 Integration with Other Planning Initiatives.

3 Risk Assessment

3.1. Exposure and Analysis of Assets at Risk and State Development Trends

Requirement for Update §201.4(d): Plan must be reviewed and revised to reflect changes in development.

3.1.1. Assets at Risk

As a starting point for analyzing the State's vulnerability to identified hazards, a variety of data is used to define a baseline against which all disaster impacts can be compared. If a catastrophic disaster was to occur in the Planning Area, this section describes significant assets exposed or at risk which could be damaged or destroyed. Data used in this baseline assessment includes:

- Total assets at risk
- General population data
- Population growth and land use/development trends
- Critical facility and bridge inventory
- Cultural, historical, and natural resources

The inventory of buildings and population that could be vulnerable to each hazard within the State is accompanied by an analysis of growth, including recent trends in population growth and housing unit development at the county level to show impacts the hazards have on both population and building assets.

Total Assets

This data presents an inventory of the total exposure of developed properties within each county. It is important to note that depending on the nature and type of hazard event or disaster, it is the value of the infrastructure or improvements to the land that is of concern or at risk. Generally, the land is not insurable and does not see a measurable reduction in use (except for lands with crops); therefore, the unimproved property should not see a reduction in value. And as such, the asset analysis excludes land value.

A summary of the estimated population and building exposure (total improved property values) by county is presented in Table A.1 of **Appendix A**. Estimated population was obtained from the US Census Bureau County Population Totals (V2019). Building exposure information was derived from inventory data associated with FEMA's loss estimation software HAZUS-MH. Content values were also included and were estimated as a percentage of building value based on their property type, using FEMA/HAZUS estimated content replacement values. Those content values are 50% for residential, 100% for commercial and governmental and 150% for industrial. All Values are in thousands of dollars. Structure counts are from the MSDIS structure database, as described in **Section 2**.

Population

Based on the U.S. Census Bureau, Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico (July 2019), Missouri ranked 18th among the 50 states in population, 22nd in population growth (numerical), 18th in land areas (68,742 square miles), and 28th in population density. In 1830, the first year of statehood, Missouri had a population of 140,455. Decennial census findings from the last few decades and the most recent estimate illustrate Missouri's growth.

Population Growth

According to the US Census, the state of Missouri had a population of 5,988,927 in 2010. In 2020, the population was estimated as 6,154,913 representing a 3% increase during this 10-year period. Counties with more than 10% growth from 2010-2019 include Boone, Christian, Clay, Lincoln, Platte, and St. Charles Counties.

Table 3.1. Missouri Population Estimates

Census	Total Population	Ten-year % Change	Average Annual % Change
1970	4,677,623	--	--
1980	4,917,444	5.13%	0.51%
1990	5,117,073	4.06%	0.41%
2000	5,595,211	9.34%	0.93%
2010	5,988,927	7.04%	0.70%
2020 (estimates base)	6,154,913	2.77%	0.28%

Source: U.S. Census Bureau Annual Estimates of the Resident Population for the United States, Regions, States, District of Columbia, and Puerto Rico: April 1, 2020 to July 1, 2021 (NST-EST2021-POP)

Table 3.2. Missouri Population Estimates

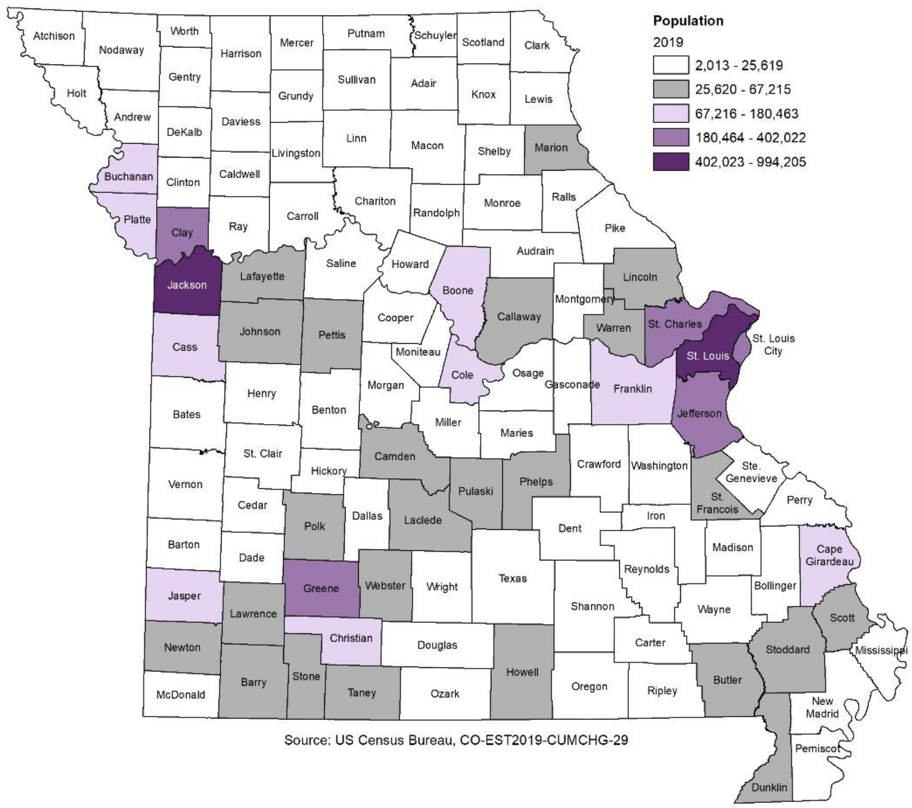
Population estimates, July 1, 2021 (V2021)	6,168,187
Population, percent change, April 1, 2020 (estimates base) to July 1, 2021 (V2021)	0.2%
Land Area in Square Miles (2010)	68,741.52
Population per Square Mile (2010)	87.1
Number of Incorporated Cities, Towns, and Villages	959
Housing Units, July 1, 2019 (V2019)	2,819,383
Number of Counties (with St. Louis City*)	115
Counties with a 2019 population estimate; Greater than 500,000	2 (St, Louis, Jackson)
200,000 to 499,000	5 (St Louis City, St. Charles, Greene, Jefferson, Clay)
100,000 to 199,99	5 (Boone, Jasper, Cass, Platte, Franklin)
50,000 to 99,999	10
25,000 to 49,999	22
15,000 to 24,999	26
10,000 to 14,999	17
1 to 9,999	28

Source: U.S. Census Bureau Quick Facts; Annual Estimates of the Resident Population for Counties in Missouri: April 1, 2010 to July 1, 2019 (CO-EST2019-ANNRES-29)

Figure 3.1 on the following page illustrates Missouri's 2019 population by county based upon the Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29).

Table 3.3 and **Figure 3.2** illustrates county population changes from 2010 to 2019 by numerical count and by percent statewide. Between 2010 and 2019, 40 counties increased in population and 13 of them grew by more than 5 percent.

Figure 3.1. Counties by Population, 2019



Source: US Census Bureau, CO-EST2019-CUMCHG-29

Table 3.3. Most Populated Missouri Counties, 2019

County	2010 Population	Ranking 2010	2019 Population	Ranking 2019	Number Change 2010-2019	Percent Change 2010-2019
St. Louis	998,985	1	994,205	1	-4,780	-0.5%
Jackson	674,166	2	703,011	2	28,845	4.3%
St. Charles	360,495	3	402,022	3	41,527	11.5%
St. Louis, City	319,289	4	300,576	4	-18,713	-5.9%
Greene	275,179	5	293,086	5	17,907	6.5%
Clay	221,906	6	249,948	6	28,042	12.6%
Jefferson	218,722	7	225,081	7	6,359	2.9%
Boone	162,652	8	180,463	8	17,811	11.0%
Jasper	117,391	9	121,328	9	3,937	3.4%
Franklin	101,468	10	103,967	12	2,499	2.5%
Cass	99,500	11	105,780	10	6,280	6.3%
Platte	89,329	12	104,418	11	15,089	16.9%

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29)

Since 2010, Cass and Platte Counties have increased in the ranking of populated counties. Franklin County has dropped out of the top ten counties with only a 2.5% increase from 2010 to 2019.

Figure 3.2. Estimated Change in Population by County, 2010-2019, Numerical

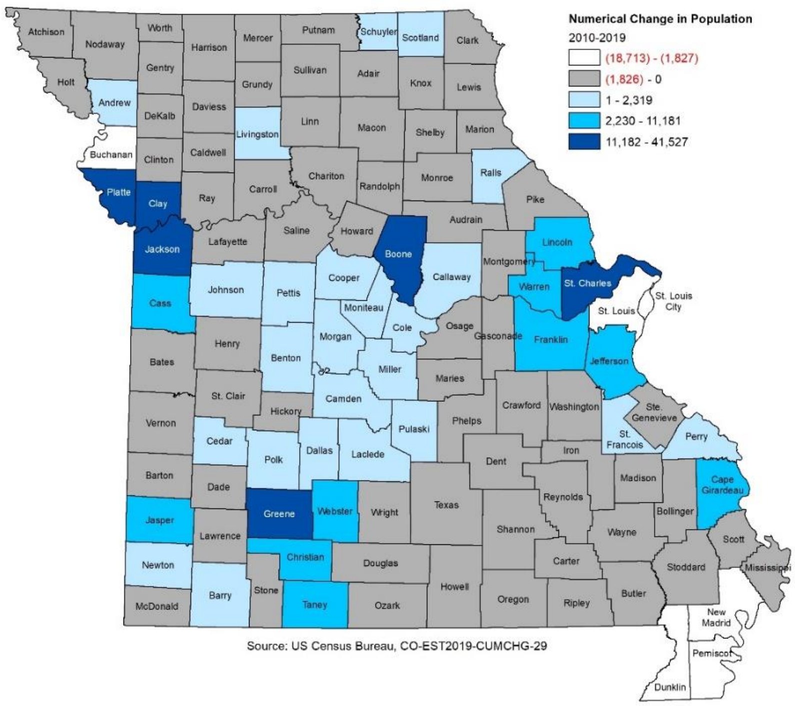
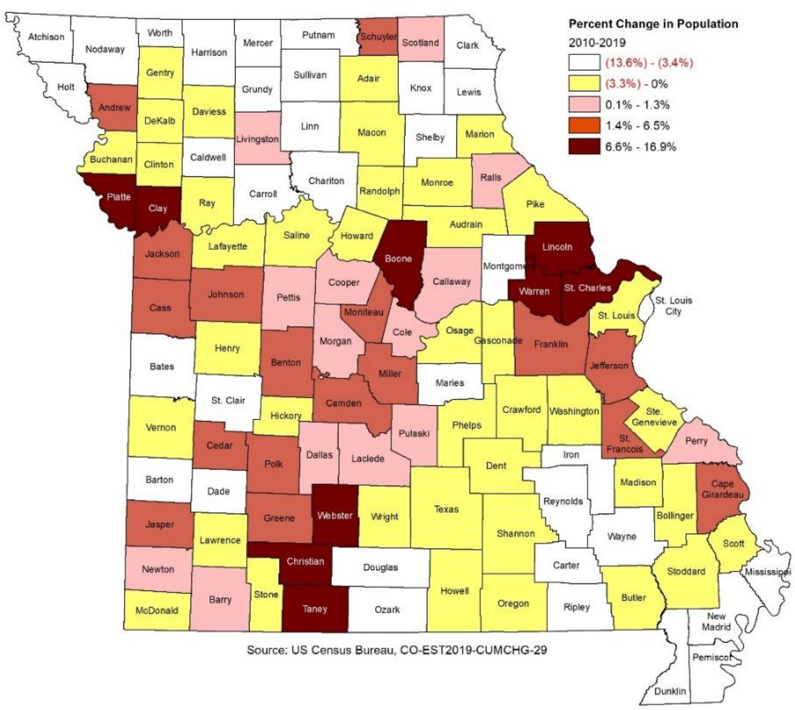


Figure 3.3. Estimated Change in Population by County, 2010-2019, Percentage



Growth in Missouri counties over the past decades can be attributed to a robust economy that led to low unemployment and reasonable interest rates. Economic resources include the following:

- The Missouri Department of Economic Development creates an environment that encourages an economic growth by supporting Missouri's businesses by providing data and resources for businesses, industries, and communities to grow and expand. The site provides a list of companies that announced their expansion projects to create jobs throughout the state.
- The Missouri Department of Higher Education & Workforce Development and the Missouri Economic Research and Information Center (MERIC) published in 2021 the "Missouri Economic & Workforce Report 2021". This report covers such economic information as gross domestic product, total personal income, unemployment, civilian labor force, nonfarm payroll employment, and employment change by industry. Highlights of this report include:
    - In 2010, Missouri produced $269.1 billion in goods and services. This increased in 2020, with Missouri producing $277.4 billion in goods and services. Missouri grew at an annualized rate of 0.3 percent to equal $8.3 billion in growth over the past 10 years, or a 3.1 percent GDP increase overall.
    - More Missourians participate in the labor force when compared to the national labor force participation rate. In July 2021, Missouri's unemployment rate was 4.2 percent, compared to the U.S. unemployment rate of 5.4 percent.
    - All Missouri regions experienced negative growth in employment from 2016 to 2020.

In addition, the Missouri Office of Administration Division of Budget & Planning describes population shifts among Missouri regions as having followed similar patterns for many years. Shifts have been from rural agricultural areas to urban areas and to rural areas rich in recreational amenities. Projections show that these patterns will continue, and there will be more movement to urban fringe areas. The demand for infrastructure and resources in the developing areas and urban fringe areas will be accompanied by the need for new hazard mitigation projects.

Table 3.4 and **Table 3.5** lists the ten counties with the greatest population growth from 2010 through 2019. For numerical population gains, Cass and Lincoln Counties have had greater gains than St. Louis and Taney Counties as reported in the previous 2018 State HMP for top 2010 to 2015 gains. For percentage population gains, Warren County has had a greater gain than Cape Girardeau as reported in the previous 2018 State HMP for top 2010 to 2015 percentage gains.

Table 3.4. Missouri Counties with Greatest Estimated Population Gains (Numerical), 2010-2019

County	2010 Population	2019 Population	Growth 2010-2019
St. Charles	360,495	402,022	41,527
Jackson	674,166	703,011	28,845
Clay	221,906	249,948	28,042
Greene	275,179	293,086	17,907
Boone	162,652	180,463	17,811
Platte	89,329	104,418	15,089
Christian	77,414	88,595	11,181
Lincoln	52,536	59,013	6,477
Jefferson	218,722	225,081	6,359
Cass	99,500	105,780	6,280

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29)

Table 3.5. Missouri Counties with Greatest Estimated Population Gains (Percent), 2010-2019

County	2010 Population	2019 Population	Growth 2010-2019
Platte	89,329	104,418	16.9%
Christian	77,414	88,595	14.4%
Clay	221,906	249,948	12.6%
Lincoln	52,536	59,013	12.3%
St. Charles	360,495	402,022	11.5%
Boone	162,652	180,463	11.0%
Warren	32,539	35,649	9.6%
Webster	36,264	39,592	9.2%
Taney	51,672	55,928	8.2%
Greene	275,179	293,086	6.5%

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29)

Not all of Missouri's counties are growing, however (refer to **Tables 3.6** and **Table 3.7**). St. Louis City, one of the most populous jurisdictions, lost the greatest number of people. For numerical population losses for 2010-2019, several counties have replaced the counties reported in the previous 2018 State HMP for 2010-2015 losses, this includes St. Louis County, Buchanan, Mississippi, Stoddard, and Scott Counties which replace Ray, Lafayette, Bates, and Wright Counties. For percentage population losses for 2010-2019, several counties again have replaced the counties reported in the previous 2018 State HMP for 2010-2015 losses, this includes New Madrid, Dunklin, Mississippi, Shelby, and Harrison Counties which replace Knox, Iron, Clark, Hickory, and Montgomery Counties.

Table 3.6. Counties with Greatest Estimated Population Loss (Numerical), 2010-2019

County	Population Decrease	Associated Percent Decrease
St. Louis City	-18,713	-5.9%
St. Louis	-4,780	-0.5%
Dunklin	-2,826	-8.8%
Pemiscot	-2,482	-13.6%
New Madrid	-1,864	-9.8%
Buchanan	-1,827	-2.0%
Nodaway	-1,281	-5.5%
Mississippi	-1,196	-8.3%
Stoddard	-943	-3.1%
Scott	-919	-2.3%

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29)

Table 3.7. Counties with Greatest Estimated Population Loss (Percent), 2010-2019

County	Population Decease	Associated Percent Decrease
Pemiscot	-2,482	-13.6%
Holt	-509	-10.4%
New Madrid	-1,864	-9.8%
Atchison	-540	-9.5%
Sullivan	-625	-9.3%
Dunklin	-2,826	-8.8%
Mississippi	-1,196	-8.3%
Worth	-156	-7.2%
Shelby	-442	-6.9%
Harrison	-609	-6.8%

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29)

Interim population projections issued by the Missouri Office of Administration in 2008 suggest that Missouri's population will continue to grow, but percentages will drop, over the next three decades (see **Table 3.8**).

Table 3.8. Missouri Population Projections, 2000-2030

Year	Population	Percent Change
2000	5,596,687	--
2005	5,781,293	3.3%
2010	5,979,344	3.4%
2015	6,184,390	3.4%
2020	6,389,850	3.3%
2025	6,580,868	3.0%
2030	6,746,762	2.5%

Source: Missouri Office of Administration, 2008

In addition to these growth projections, the following counties are expected to experience a population decrease of 5 percent or greater by 2030 (see **Table 3.9**).

Table 3.9. Counties Projected to Have Future Population Decreases (In order of percent decline by 2020 and 2030)

Counties	2015	Population Projections					
		2020 (Proj)	2030 (Proj)	# Decline by 2020	# Decline by 2030	% Decline by 2020	% Decline by 2030
New Madrid	15,764	14,621	12,554	1,143	3,210	-7.25%	-20.36%
Iron	9,158	8,605	7,494	553	1,664	-6.04%	-18.17%
Gentry	5,637	5,314	4,759	323	878	-5.73%	-15.58%
Chariton	7,178	6,832	6,172	346	1,006	-4.82%	-14.02%
Holt	4,591	4,428	4,094	163	497	-3.55%	-10.83%
Mississippi	12,784	12,285	11,443	499	1,341	-3.90%	-10.49%
Linn	11,898	11,477	10,696	421	1,202	-3.54%	-10.10%
Wayne	12,378	12,001	11,200	377	1,178	-3.05%	-9.52%
Pemiscot	17,856	17,324	16,447	532	1,409	-2.98%	-7.89%
Atchison	5,715	5,559	5,280	156	435	-2.73%	-7.61%
Worth	1,975	1,917	1,826	58	149	-2.94%	-7.54%
Shelby	6,223	6,067	5,764	156	459	-2.51%	-7.38%
Carroll	9,489	9,232	8,816	257	673	-2.71%	-7.09%
Sullivan	6,253	6,033	5,822	220	431	-3.52%	-6.89%
Putnam	4,680	4,545	4,391	135	289	-2.88%	-6.18%
Dade	7,434	7,294	6,977	140	457	-1.88%	-6.15%
Dunklin	30,575	29,870	28,765	705	1,810	-2.31%	-5.92%
Ozark	8,981	8,804	8,457	177	524	-1.97%	-5.83%
Statewide Total[1]	**6,184,390**	**6,389,850**	**6,746,762**	**+205,460**	**+562,372**	**+3.32%**	**+9.09%**

[1] Statewide populations are expected to increase.
Source: Missouri Office of Administration, 2008

Housing Units

A good indicator of growth is the number of housing units. The census defines a housing unit as a house, an apartment, a mobile home or trailer, a group of rooms, or a single room that is occupied, or, if vacant, is intended for occupancy as separate living quarters. According to the U.S. Census Bureau, the number of estimated housing units in Missouri increased 3.9 percent (104,756 units) between 2010 and 2019. Boone County, Christian County, and St. Charles County topped the list for percent growth of housing units.

Table 3.10 and **Table 3.11** list the counties that have grown the most in terms of housing units by number and percent respectively. **Figure 3.4** and **Figure 3.5** illustrate these changes statewide. Since the 2018 State HMP, St. Louis and Cass Counties have replaced Taney and St. Francois Counties with top numerical housing unit gains. Additionally, Platte, Warren, Greene, Cape Girardeau, and Cass Counties have replaced Taney, Worth, Stone, Putnam, and Lincoln Counties for top percentage housing unit gains.

Table 3.10. Counties with Greatest Estimated Housing Unit Gains (Numerical), 2010-2019

County	Housing Unit Numerical Increase	Housing Unit Associated Percent Increase
St. Charles	17,040	12.1%
Jackson	16,085	5.2%
Greene	10,069	8.0%
Boone	9,659	13.9%
Clay	5,741	6.1%
Jefferson	4,378	5.0%
St. Louis	4,261	1.0%
Christian	3,684	11.6%
Platte	3,587	9.1%
Cass	2,812	7.0%

Source: U.S. Census Bureau, Annual Estimates of Housing Units for Counties in Missouri:
April 1, 2010 to July 1, 2019 (CO-EST2019-ANNHU-29)

Table 3.11. Counties with Greatest Estimated Housing Unit Gains (%), 2010-2019

County	Housing Unit Percent Increase	Housing Unit Associated Numerical Increase
Boone	13.9%	9,659
St. Charles	12.1%	17,040
Christian	11.6%	3,684
Platte	9.1%	3,587
Warren	8.9%	1,317
Greene	8.0%	10,069
Cape Girardeau	7.1%	2,326
Cass	7.0%	2,812
Pulaski	6.9%	1,232
St. Francois	6.7%	1,909

Source: U.S. Census Bureau, Annual Estimates of Housing Units for Counties in Missouri:
April 1, 2010 to July 1, 2019 (CO-EST2019-ANNHU-29)

Figure 3.4. Estimated Change in Housing Units by County, 2010-2019, Numerical

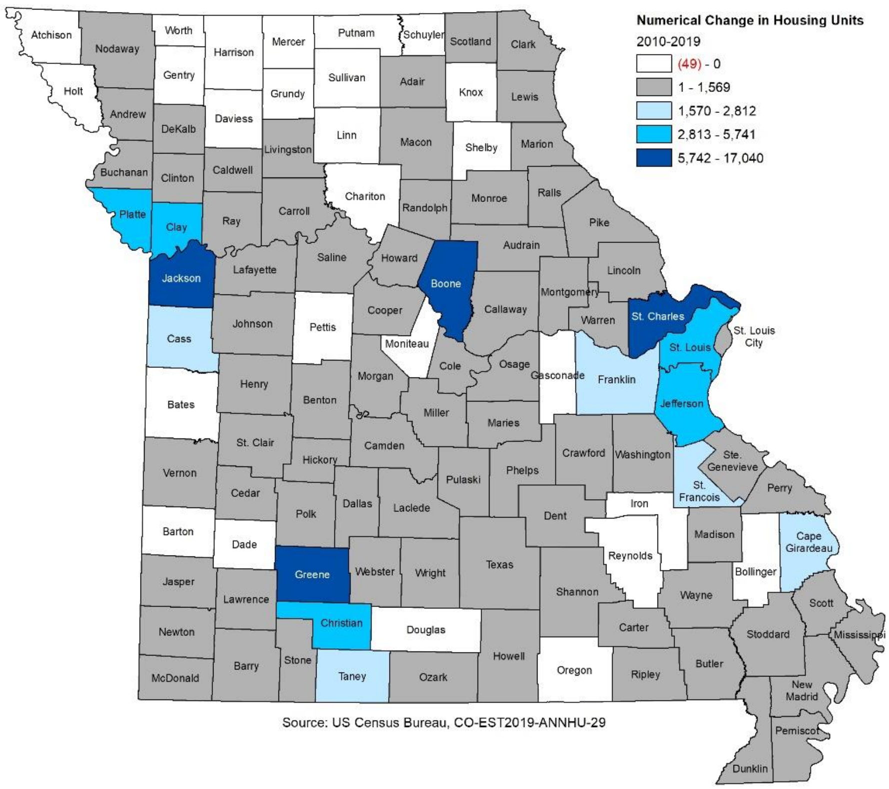
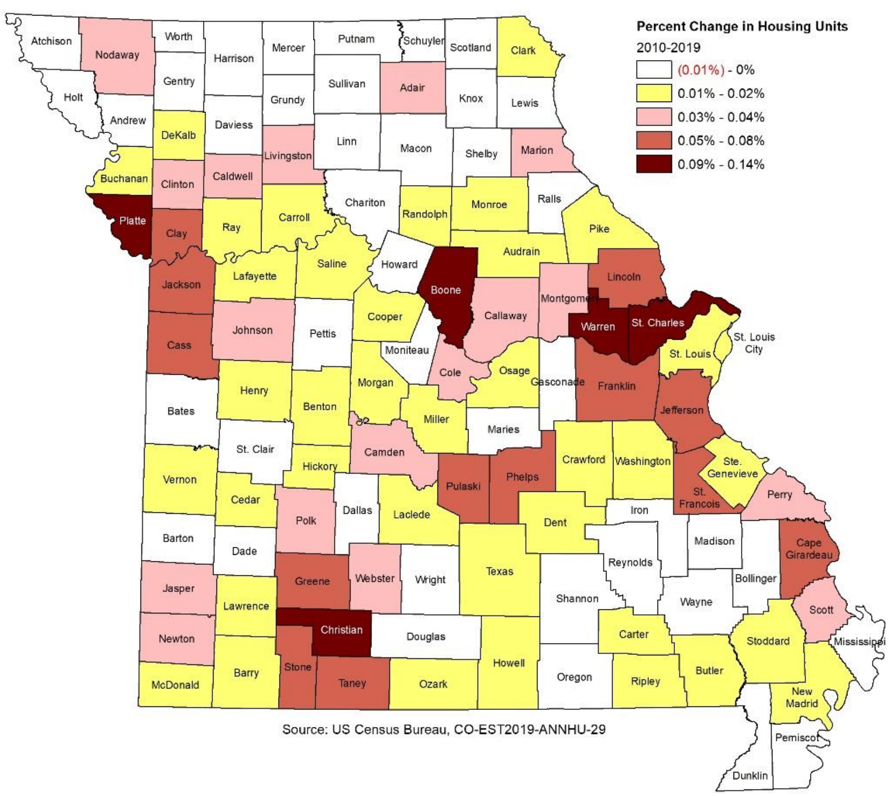


Figure 3.5. Estimated Change in Housing Units by County, 2010-2019, Percentage



Population Density

Missouri has a surface land area of 68,724 square miles and a population of 6,137,428 (2019 Census estimate). Based on the 2019 census estimates, Missouri ranked 18th in population among the 50 states**. Table 3.12** and **Figure 3.6** presents population density and population density growth. Density is reported as people per housing units per square mile and is based on the square mileage of the counties in the 2010 census.

Table 3.12. Top 10 Counties Ranked by Population/Housing Density, 2019

County	2019 Population Density	Population Density Change (%) 2010-2019	2019 Estimated Housing Density*	Housing Density* Change (%) 2010-2019
St. Louis City	4855.05	-5.86%	2865.50	0.83%
St. Louis	1957.87	-0.48%	871.01	0.97%
Jackson	1163.04	4.28%	543.08	5.15%
St. Charles	717.33	11.52%	282.62	12.05%
Clay	629.12	12.64%	250.91	6.11%
Greene	434.01	6.51%	200.86	8.02%
Jefferson	342.78	2.91%	140.32	4.99%
Boone	263.29	10.95%	115.78	13.86%
Platte	248.50	16.89%	101.95	9.14%
Buchanan	214.11	-2.05%	95.14	0.99%

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29); U.S. Census Bureau, Annual Estimates of Housing Units for Counties in Missouri: April 1, 2010 to July 1, 2019 (CO-EST2019-ANNHU-29)
Notes: *Density is reported as people/housing units per square mile and is based on the square mileage of the counties in the 2010 census
**St. Louis City* is considered both a "place" and a "county" by the U.S. Census Bureau, so it is treated here as a as well as a city

There is a direct correlation between the rate of growth in counties and increase in population density as is shown in **Table 3.13** and **Figure 3.7**.

Table 3.13. Counties with Greatest Estimated Population Density Gains (Percent), 2010-2019

County	2010 Estimated Population Density	2019 Estimated Population Density	Population Density* Change (%) 2010-2019
Platte	212.59	248.50	16.89%
Christian	137.59	157.46	14.44%
Clay	558.54	629.12	12.64%
Lincoln	83.85	94.19	12.33%
St. Charles	643.24	717.33	11.52%
Boone	237.31	263.29	10.95%
Warren	75.92	83.18	9.56%
Webster	61.20	66.82	9.18%
Taney	81.70	88.43	8.24%
Greene	407.49	434.01	6.51%

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010, to July 1, 2019 (CO-EST2019-CUMCHG-29)

Figure 3.6. Population Density by County, 2019

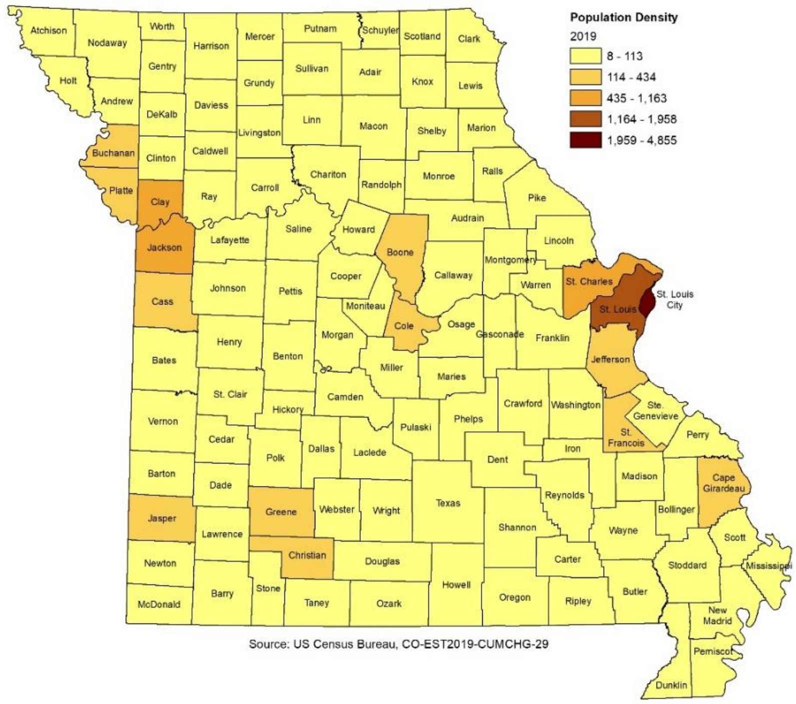
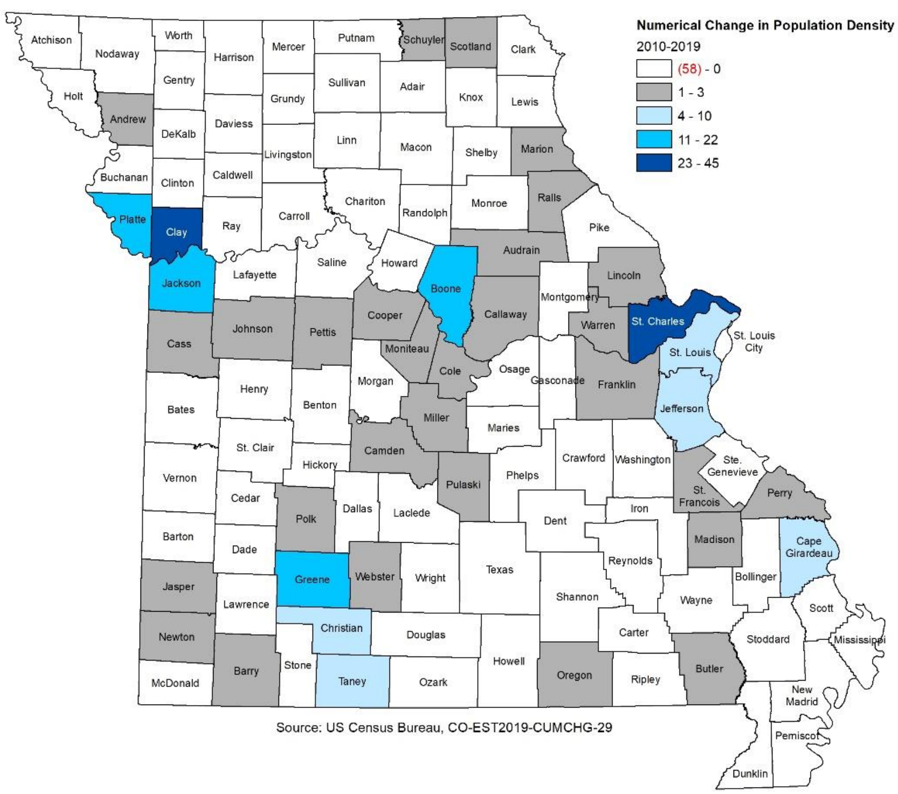


Figure 3.7. Estimated Change in Population Density by County, 2010-2019, Percentage



Critical Facilities / Infrastructure – State Owned and/or Operated

For the purposes of this plan, a critical facility is defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. FEMA's Hazus-MH loss estimation software uses the following three categories of critical assets:

- Essential facilities are those that if damaged would have devastating impacts on disaster response and/or recovery
- High potential loss facilities are those that would have a high loss or impact on the community
- Transportation and lifeline facilities are a third category of critical assets, consisting of transportation systems and utilities

Table 3.102 summarizes state facilities data obtained for this 2023 plan update.

Table 3.14. State Facilities Inventories

Source/Inventory	2010 # of Facilities Geolocated	2013 # of Facilities Geolocated	2018 # of Facilities Geolocated	2022 # of Facilities Geolocated
Office of Administration/State Facilities—includes the following: Department of Agriculture (DOA) Department of Corrections (DOC) Department of Economic Development (DED) Department of Elementary and Secondary Education (DESE) Department of Labor and Industrial Relations (DLIR) Department of Mental Health (DMH) Department of Natural Resources (MoDNR) Department of Revenue (DOR) Department of Social Services (DOSS) Department of Public Safety (DPS)	3,477 (Owned) 0 (Leased)	3,437 (Owned) 959 (Leased)	7,229 (Owned) 954 (Leased)	7,229 (Owned) 612 (Leased)
Missouri Department of Transportation (MoDOT) Facilities Bridges	 0 7,124	 175 10,361	 295 10,400	 295 10,400
Department of Higher Education (DHE) /Public Colleges and Universities	143	89	455	2,453
Missouri Department of Conservation (MDC)	688	0	1,511	1,511

For Missouri state-owned or operated facilities provided by the Office of Administration, Missouri Department of Transportation (MoDOT), and Missouri Department of Conservation (MDC) the State applied FEMA's guidelines for determining critical facilities to the asset use/facility types. A total of 2,090 facilities were determined to be critical facilities. For the MoDOT State Bridge Inventory, all 10,400 state-owned bridges in Missouri were considered critical.

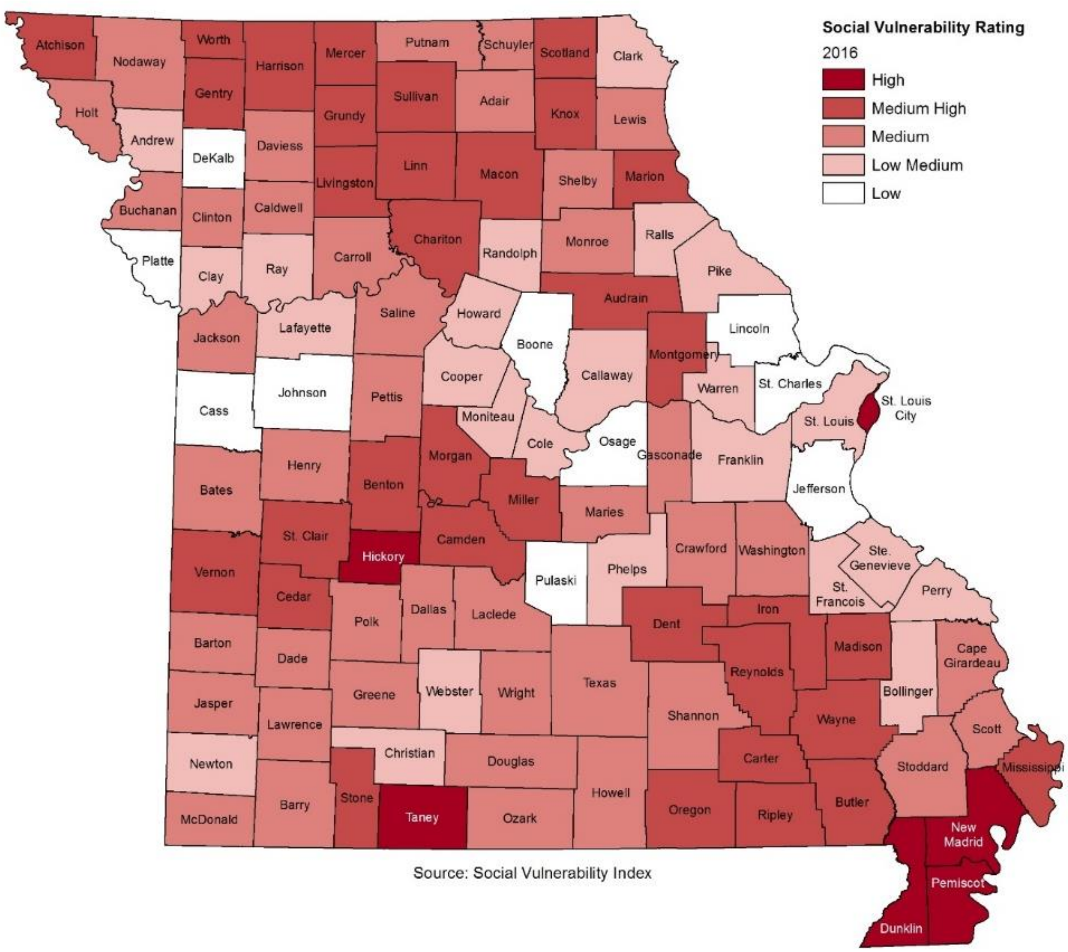
Section 3.5 State Owned and Operated Facilities: Vulnerability and Loss Estimates, provides additional detailed information on critical facilities and infrastructure for the State.

Social Vulnerability

A Social Vulnerability Index compiled by the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina measures the social vulnerability of U.S. counties to environmental hazards for the purpose of examining the differences in social vulnerability among counties. It synthesizes 42 socioeconomic and built environment variables that research literature suggests contributes to reduction in a community's ability to prepare for, respond to, and recover from hazards (i.e., social vulnerability). Eleven composite factors were identified that differentiate counties according to their relative level of social vulnerability: personal wealth, age, density of the built environment, single-sector economic dependence, housing stock and tenancy, race ethnicity, occupation, and infrastructure dependence.

The index can be used by the state to help determine where social vulnerability and exposure to hazards overlaps and how and where mitigation resources might best be used. **Figure 3.8** illustrates Missouri's geographic variation in social vulnerability. Social vulnerability rankings are mapped using quantiles. Scores in the top 20% are more vulnerable counties (High, dark red) and scores in the bottom 20% indicate the least vulnerable counties (Low, white). According to the social vulnerability index, the following counties are Missouri's most vulnerable: Dunklin, Hickory, New Madrid, Pemiscot, St. Louis City, and Taney.

Figure 3.8. Social Vulnerability Rating, 2010-2014



Cultural and Historic Resources

Cultural resources play an important role in preserving the identity of cultures within a state. Ensuring that these resources are maintained for future generations to enjoy is of extreme importance. Therefore, the vulnerability of these resources to natural disasters means that inventorying the natural, historical, and cultural assets in a community is critical. Inventorying resources is important for the following reasons: The community may decide that these types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.

In the event of a disaster, an accurate inventory of natural, historical and cultural resources allows for more prudent care in the disaster's immediate aftermath when the potential for additional impacts is higher.

The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.

- Natural resources can have beneficial functions that reduce the impacts of natural hazards, for example, wetlands and riparian habitat which help absorb and attenuate floodwaters and thus support overall mitigation objectives.

Cultural and Historical Resources
Missouri has numerous historically significant homes, public buildings, and landmarks. The Missouri State Historic Preservation Office is the agency authorized to carry out the responsibilities of the National Historic Preservation Act of 1966, as amended. These activities include: reviewing nominations to the National Register of Historic Places, overseeing the state's architectural and archaeological survey programs, Section 106 Review and Compliance, managing Missouri's Certified Local Government Program, reviewing state and federal historic tax credit applications, and administering Historic Preservation Grant programs.

The National Register of Historic Places is the nation's official list of cultural resources worthy of preservation. The National Register is part of a program to coordinate and support public and private efforts to identify, evaluate, and protect historic and archeological resources. Properties listed on the National Register include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archeology, engineering, and culture. The number of historic places by county is presented in **Appendix A, Table A.5**.

It should be noted that the number of Historic Places changes periodically due to those currently in the nomination process which may not yet be listed in a community. Additionally, as defined by the National Environmental Policy Act (NEPA), any property over 50 years of age is considered a historic resource and is potentially eligible for the National Register. Thus, if the property is to be altered, has been altered as the result of federal action, the property must be evaluated under the guidelines set forth by NEPA. Structural mitigation projects are considered alterations for the purpose of this regulation.

Many cultural and historical resources in Missouri are vulnerable to several hazards due to the nature of their design and construction and their location. Some of these risks include floods, earthquakes, wildfires and high winds.

Natural Resources

Natural resources are important to include in benefit/cost analyses for future projects. They may be used to leverage additional funding for mitigation projects and can also contribute to community goals for protecting sensitive or endangered resources. Awareness of natural assets can lead to opportunities for meeting multiple objectives. For instance, protecting wetlands areas also protects sensitive habitat as well as

providing for the storage of floodwaters. The GIS Mapping data of wetland areas across Missouri is further described in **Section 3.3** Hazard Profiles and State Risk Assessment. It can also be obtained from SEMA by contacting the SHMO.

Natural and Beneficial Functions

Floodplains have natural and beneficial functions. Wetlands function as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater and flood waters. Trees, root mats, and other wetland vegetation also slow the speed of floodwaters and distribute them more slowly over the floodplain. This combined water storage and braking action lowers flood heights and reduces erosion. Wetlands within and downstream of urban areas are particularly valuable, counteracting the increased rate and volume of surface water runoff from impervious surfaces such as pavement and buildings. The holding capacity of wetlands helps control floods and prevents water logging of crops. Preserving and restoring wetlands, together with other water retention and detention, can often provide the level of flood control otherwise provided by dredge operations and levees.

Special Status Species

To further understand natural resources that may be particularly vulnerable to a hazard event, as well as those that need consideration when implementing mitigation activities, it is important to identify at-risk species (i.e., endangered species) in the planning area. The US Fish and Wildlife Service maintains a list of threatened and endangered species in Missouri. There are 36 threatened and endangered species believed to or are known to occur in Missouri. State and federal laws protect the habitat of these species through the environmental review process. Several additional species are of special concern or candidates to make the protected list.

3.1.2. Development Trends

Counties with growing populations and acceleration in housing will have increased vulnerability to hazard events such as tornadoes and floods. This includes the following counties experiencing growth:

- Boone
- Cape Girardeau
- Cass
- Christian
- Clay
- Greene
- Jackson
- Jefferson
- Lincoln
- Platte
- Pulaski
- St. Charles
- St. Francois
- St. Louis
- Taney
- Warren
- Webster

Most counties experiencing development pressures participate in the National Flood Insurance Program. Even though these counties and communities have a flood damage prevention ordinance, this does not mean the flood risk should be less. Incorporation of higher regulatory standards is one way in which counties can better protect building, infrastructure, and save lives.

Extreme southeastern Missouri counties are experiencing little (less than 5 percent) or no growth. Rural communities with declining populations and housing will have increased vulnerability to weather-related hazards and a lower resilience to loss because there is reduced or little surplus capacity to absorb crop or livestock income losses. Even small losses might feed back into poverty and future vulnerability. Additionally, declining population and housing may also result in fewer number of response and recovery resources, such

as fire departments and medical facilities. While counties are not experiencing development pressure, participation in the NFIP remains a recommended mitigation measure.

Rural counties experiencing declining population and housing includes the following:

- Atchison
- Dunklin
- Harrison
- Holt
- Mississippi
- New Madrid
- Nodaway
- Pemiscot
- Scott
- Shelby
- Stoddard
- Sullivan

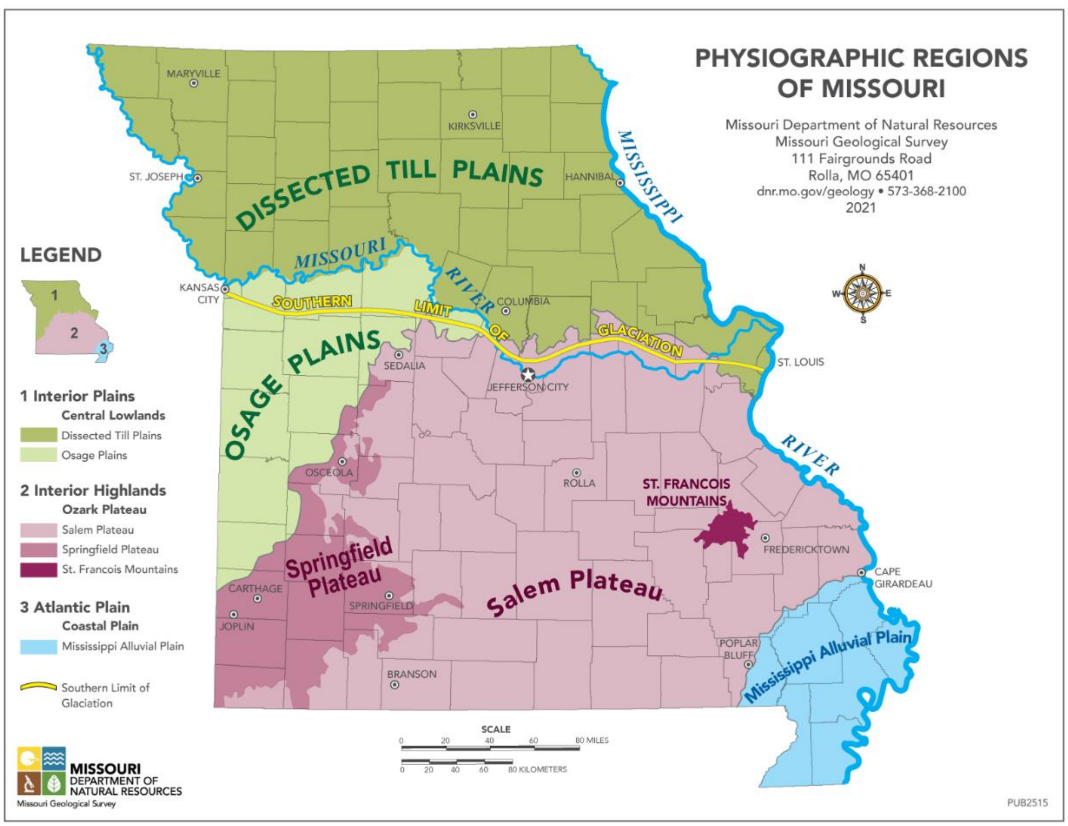
3.2. Hazard Identification

Requirement §201.4(c)(2)(i): The state risk assessment shall include an] overview of the type…of all natural hazards that can affect the State.

Located within the central portion of the United States, Missouri is prone to several kinds of natural hazards. Missouri has a continental climate; the weather is changeable and has wide variations in temperature and precipitation. There are three distinct physiographic regions: interior plains in the north and west, interior highlands in the south, and alluvial plains in the extreme southeast.

- The plains regions, both glaciated and unglaciated, encompasses nearly all the area north of the Missouri River and a large area south of the river in the western part of the State. The topography varies from rolling hills in the east to hills in the west that average about 450 feet above sea level. There are numerous wide, flat valleys cut by the river and its tributaries.
- The interior highlands, which comprise about half of the State, are characterized by rugged areas of sharp ridges and deep narrow valleys. Elevations range from about 1,000 to more than 1,600 feet above sea level.
- The southeastern alluvial plains cover about 3,000 square miles, with elevations from 230 to 300 feet above sea level. Much of the region is excellent farmland, channeled by an extensive system of drainage ditches.

Figure 3.9. Physiographic Regions of Missouri



Source: MO Department of Natural Resources, Missouri Geological Survey

The State is situated along two of the continent's greatest rivers, the Missouri and the Mississippi. As a result, the potential for great floods is high. While six large flood control dams have been built on the mainstream of the Missouri River, they have lessened but not eliminated the flood threat. Most of the natural disasters that occur in Missouri (except for earthquakes, land subsidence and possibly dam failures) result from a weather extreme or an extreme weather change. Because Missouri is situated in the center of the United States, it is subject to many different influences that determine weather patterns. Warm and cool air masses often collide along sharply divided fronts, accompanied by violent thunderstorms having intense rains, strong winds, hail, lightning, and tornadoes. These frontal storm systems can pass across the State at any time of the year, but are most frequent during the spring months (March, April and May). There are two important truths about Missouri's weather: 1) the State is subject to weather extremes, and 2) extreme weather changes can occur rather quickly. Additional information on weather patterns is presented in **Appendix A**.

Missouri also serves as a major thoroughfare for transportation and has an abundant share of industrial, agricultural, and recreational facilities. Thus, human-caused/technological disasters can also occur, such as hazardous materials releases, nuclear facility incidents and other emergencies caused by human action.

This State Hazard Mitigation Plan considers natural, human-caused, technological, and other hazards as discussed in the following sections.

3.2.1. Natural Hazards

Natural hazards can be complex, occurring with a wide range of intensities. Some events are instantaneous and offer no window of warning, such as earthquakes. Some offer a short window in which to alert the public to take actions, such as tornadoes or severe thunderstorms. Others occur less frequently and are typically more expansive, with some warning time to allow the public time to prepare, such as river flooding. The following natural hazards threaten Missouri.

Flooding (Major and Flash) Levee Failure Dam Failure	Natural Flood-Related Hazards
Earthquake Land Subsidence / Sinkholes	Natural Geologic Hazards
Drought Extreme Temperature Severe Thunderstorms Severe Winter Weather Tornadoes	Natural Meteorological Hazards
Wildfire	Natural Other Hazard

The list above of natural hazards is the same as those identified in the previous 2018 State Hazard Mitigation Plan Update. **Table 3.15** below identifies the natural hazards that were excluded from the State Risk Assessment along with the reason for their exclusion.

Table 3.15. Natural Hazards Excluded from State Risk Assessment

Hazard	Reason for Exclusion
Avalanche	No identified avalanche risk areas and no history of occurrence.
Coastal Erosion	No coastal areas in Missouri.
Coastal Storms	No coastal areas in Missouri.
Expansive Soils	Expansive soils are a limited risk with no identified risk areas, per MoDNR.
Hurricanes	Missouri is an inland state. Although in 2008 Hurricane Ike did indirectly cause severe weather in Missouri, it was the resulting hazards that are profiled (flooding, winds, hail, and tornadoes) that directly affected Missouri.
Landslide/Rockfall	Landslide/Rockfall is not considered to be a widespread hazard of concern in the state, per MoDOT. Although there are areas within the state where landslide/rockfall can potentially impact roadways, these risk areas and any identified mitigation fall under the jurisdiction of MoDOT. It was determined that additional analysis of these limited areas would duplicate effort.
Tsunamis	Missouri is an inland state.
Volcanoes	No identified volcanoes in Missouri.

3.2.2. Human-Caused / Technological Hazards

Each year there are increases in human-caused/technological incidents which can be just as devastating as natural disasters. The following human-caused/technological hazard that can threaten Missouri are included in the State Risk Assessment:

- Civil Disorder
- Cyber Disruption
- Environmental Health Emergencies
- Hazardous Materials
- Mass Transportation Accidents
- Nuclear Power Plants (Fixed Nuclear Facilities)
- Public Health Emergencies
- Special Events
- Terrorism, including CBRNE Attack (Chemical, Biological, Radiological, Nuclear and Explosive)
- Urban/Structure Fire
- Utilities (Interruptions and System Failures)

Since the previous 2018 State Hazard Mitigation Plan Update, the hazard of Terrorism has been combined with the hazard CBRNE Attack. A CBRNE Attack is a terrorism action and the SRMT felt it was best served to combine these hazards and not duplicate vulnerability analysis and assessment of risk. Additionally, the hazard of Public Health and Environmental Health Emergencies has been split into two distinct hazards to better address the vulnerability analysis and assessment of risk for each.

3.2.3. Disaster Declarations

In the United States, 95 percent of all presidentially declared major disasters have been related to weather or flood events. In Missouri, all of the presidentially declared major disasters since 1975 have been related to weather or flood events with the exception of the COVID-19 pandemic, as declared in 2020. Since the 2018 update of the State Hazard Mitigation Plan, there have been seven presidential disaster declarations (See **Table 3.3**). Of these seven disasters, six were major disaster declarations and one was an emergency

declaration. **Table 3.16** summarizes presidential major disaster declarations, emergency declarations and fire management assistance declarations for Missouri since 1975.

Figure 3.10 illustrates the declared disasters in Missouri by County from 1965 to January 2022. Additional information on presidential declared disasters can be found at https://www.fema.gov/disaster/declarations.

Table 3.16. Presidential Disaster Declarations for Missouri, 1975-January 2022

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
Major Disaster Declarations				
May 3, 1975	DR-466	Tornadoes, High Winds, Hail	4	IA & PA: 4
July 21, 1976	DR-516	Severe Storms, Flooding	4	IA & PA: 4
May 7, 1977	DR-535	Tornadoes, Flooding	7	IA & PA: 7
September 14, 1977	DR-538	Severe Storms, Flooding	6	IA & PA: 6
April 21, 1979	DR-579	Tornadoes, Torrential Rain, Flooding	17	IA Only: 1 IA & PA: 16
May 15, 1980	DR-620	Severe Storms, Tornadoes	1	IA Only: 1
August 26, 1982	DR-667	Severe Storms, Flooding	3	IA Only: 1 IA & PA: 2
December 10, 1982	DR-672	Severe Storms, Flooding	17	IA Only: 18 PA Only: 1 IA & PA: 5
June 21, 1984	DR-713	Severe Storms, Flooding	11	IA Only: 1 PA Only: 8 IA & PA: 2
October 14, 1986	DR-779	Severe Storms, Flooding	30	IA Only: 7 PA Only: 15 IA & PA: 8
May 24, 1990	DR-867	Flooding, Severe Storm	10	IA Only: 2 IA & PA: 8
May 11, 1993	DR-989	Severe Storm, Flooding	8	IA Only: 8
July 9, 1993	DR-995	Flooding, Severe Storm	101 and St. Louis City	IA Only: 14 IA & PA: 88
December 1, 1993	DR-1006	Flooding, Severe Storm, Tornadoes	24	IA Only: 10 IA and PA: 14
April 21, 1994	DR-1023	Severe Storm, Flooding, Tornadoes	17 and St. Louis City	IA Only: 18
June 2, 1995	DR-1054	Severe Storm, Tornadoes, Hail, Flooding	61 and St. Louis City	IA Only: 19 IA & PA: 43
October 14, 1998	DR-1253	Severe Storm and Flooding	19	IA and PA: 5 PA Only: 14
October 19, 1998	DR-1256	Severe Storm and Flooding	2 and St. Louis City	IA Only: 3
April 20, 1999	DR-1270	Severe Storms and Flooding	6	IA Only: 6
May 12, 2000	DR-1328	Severe Thunderstorms and Flash Flooding	10	IA: 10 IA and PA: 3
February 6, 2002	DR-1403	Ice Storm	43	IA Only: 17 IA and PA: 26
May 6, 2002	DR-1412	Severe Storms and Tornadoes	79	IA Only: 9 PA Only: 31 IA and PA: 39
May 6, 2003	DR-1463	Severe Storms, Tornadoes, and Flooding	76	IA Only: 42 PA Only: 2 IA and PA: 32
June 11, 2004	DR-1524	Severe Storms, Tornadoes, and Flooding	37	IA: 37

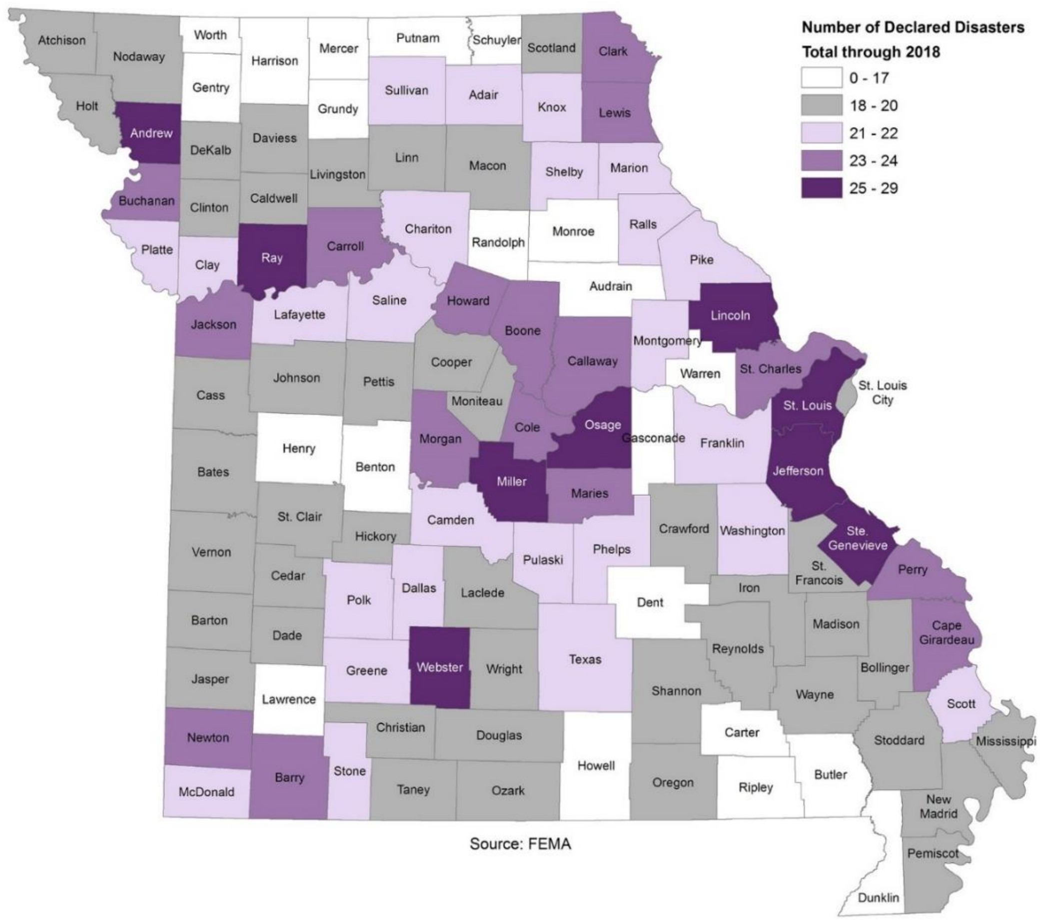
Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
March 16, 2006	DR-1631	Severe Storms, Tornadoes, and Flooding	41	IA Only: 12 PA Only: 4 IA and PA: 25
April 5, 2006	DR-1635	Severe Storms, Tornadoes, and Flooding	7	IA Only: 3 IA and PA: 4
November 2, 2006	DR-1667	Severe Storms	St. Louis City	PA Only: 1
December 29, 2006	DR-1673	Severe Winter Storms	13 and St. Louis City	PA Only: 14
January 15, 2007	DR-1676	Severe Winter Storms and Flooding	38 and St. Louis City	PA Only: 39
June 11, 2007	DR-1708	Severe Storms and Flooding	30	IA Only: 6 PA Only: 12 IA and PA: 12
September 21, 2007	DR-1728	Severe Storms and Flooding	7	PA Only
December 27, 2007	DR-1736	Severe Winter Storms	42	PA Only
February 5, 2008	DR-1742	Severe Storms, Tornadoes, and Flooding	9	PA Only
March 12, 2008	DR-1748	Severe Winter Storms and Flooding	18	PA Only
March 19, 2008	DR-1749	Severe Storms and Flooding	56	IA Only: 5 PA Only: 21 IA and PA: 30
May 23, 2008	DR-1760	Severe Storms and Tornadoes	3	IA Only
June 25, 2008	DR-1773	Severe Storms and Flooding	53	IA Only: 3 PA Only: 26 IA and PA: 24
November 13, 2008	DR-1809	Severe Storms, Flooding, and a Tornado	56	IA Only: 7 PA Only: 26 IA and PA: 12
February 17, 2009	DR-1822	Severe Winter Storm	21	PA Only
June 19, 2009	DR-1847	Severe Storms, Tornadoes, and Flooding	52	PA Only: 24 IA Only: 4 IA and PA: 24
August 17, 2010	DR-1934	Severe Storms, Flooding, and Tornadoes	37	PA Only
March 23, 2011	DR-1961	Severe Winter Storm and Snowstorm	62	PA Only
May 9, 2011	DR-1980	Severe Storms, Tornadoes, and Flooding	38	PA Only: 13 IA and PA: 25
August 12, 2011	DR-4012	Severe Storms, Tornadoes, and Flooding	10	PA Only: 4 IA and PA: 6
July 18, 2013	DR-4130	Severe Storms, Straight-Line Winds, Tornadoes, and Flooding	28	PA Only
September 6, 2013	DR-4144	Severe Storms, Straight-Line Winds and Flooding	18	PA Only
October 31, 2014	DR-4200	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	20	PA Only
August 7, 2015	DR-4238	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	76	PA Only
January 21, 2016	DR-4250	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	52	IA Only: 10 PA Only: 19 IA and PA: 23
June 2, 2017	DR-4317	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	56	IA Only: 2 PA Only: 20 IA and PA: 34
May 20, 2019	DR-4435	Severe Storms, Straight-line Winds, and Flooding	13	PA Only
July 9, 2019	DR-4451	Severe Storms, Tornadoes, and Flooding	86 and St. Louis City	IA Only: 4 PA Only: 61 IA and PA: 22

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
March 26, 2020	DR-4490	COVID-19 Pandemic	114 and St. Louis City	IA and PA
July 9, 2020	DR-4552	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	19	PA Only
September 1, 2021	DR-4612	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	21	PA Only
January 10, 2022	DR-4636	Severe Storms, Tornadoes, and Straight-Line Winds	7	PA Only
Emergency Declarations				
September 24, 1976	EM-3017	Drought	94	PA Only
March 12, 1979	EM-3071	Ice Jam, Flooding	2	PA Only
September 10, 2005	EM-3232	Hurricane Katrina Evacuation	114 and St. Louis City	PA Only: 115
July 21, 2006	EM-3267	Severe Storms	7 and St. Louis City	PA Only: 8
December 12, 2007	EM-3281	Severe Winter Storms	116	PA Only
January 30, 2009	EM-3303	Severe Winter Storms	115	PA Only
January 2, 2016	EM-3374	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	73	PA Only
March 13, 2020	EM-3482	COVID-19	114 and St. Louis City	PA Only
Fire Management Assistance				
March 9, 2000	FMA-2292	Camden Fire Complex	n/a	n/a

Source: Federal Emergency Management Agency

Notes: *IA denotes Individual Assistance; PA denotes Public Assistance

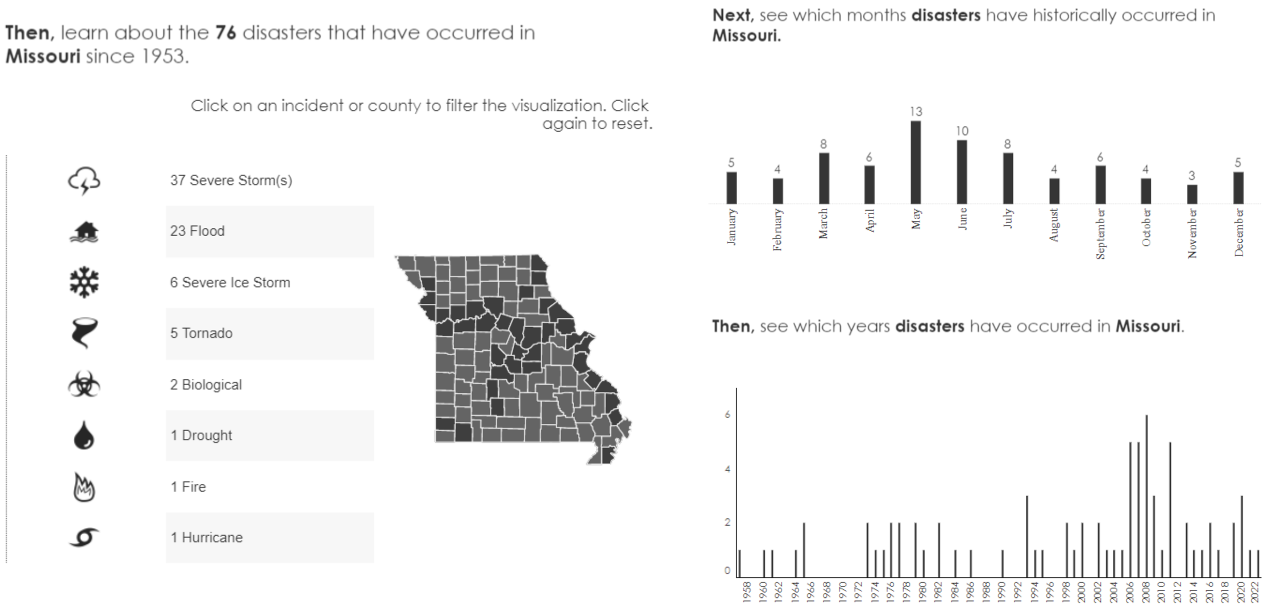
Figure 3.10. Presidentially Declared Disasters by County in Missouri, 1965-January 2022



Source: FEMA; https://www.fema.gov/disaster/declarations.

Since 1953, most of Missouri's federally declared disasters have occurred during the months of March, April, and September; have been for severe storms; and present a spike in declarations from 2005 to 2008 and again in 2011. A graphical representation of this information is presented in **Figure 3.11**. Additional data visualizations include FEMA's Individual and Household Program data and the Small Business Administration's Disaster Home Loan Program data (**Figure 3.12**) and Public Assistance Program Summary of Obligations (**Figure 3.13**). From these two figures, it is shown that FEMA has provided over $105 million for Individual Assistance and over $1.3 billion for the Public Assistance program. During this time period Mitigation, Public Assistance and Individual Assistance funding totaled over $1.4 Billion.

Figure 3.11. Missouri Declarations by Incident Type and Year, 1953 to January 2022



Source: Federal Emergency Management Agency, [Disaster Declarations for States and Counties | FEMA.gov]

Figure 3.12. FEMA Individual Assistance and SBA Disaster Home Loans, 2005-2018

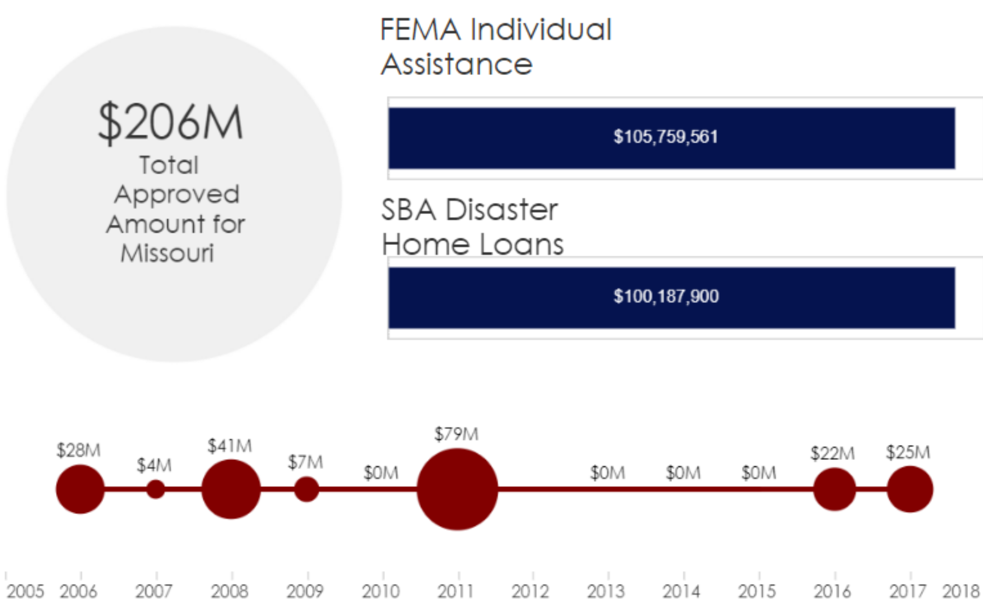


Figure 3.13. FEMA Public Assistance Obligations, 2003 - January 2022

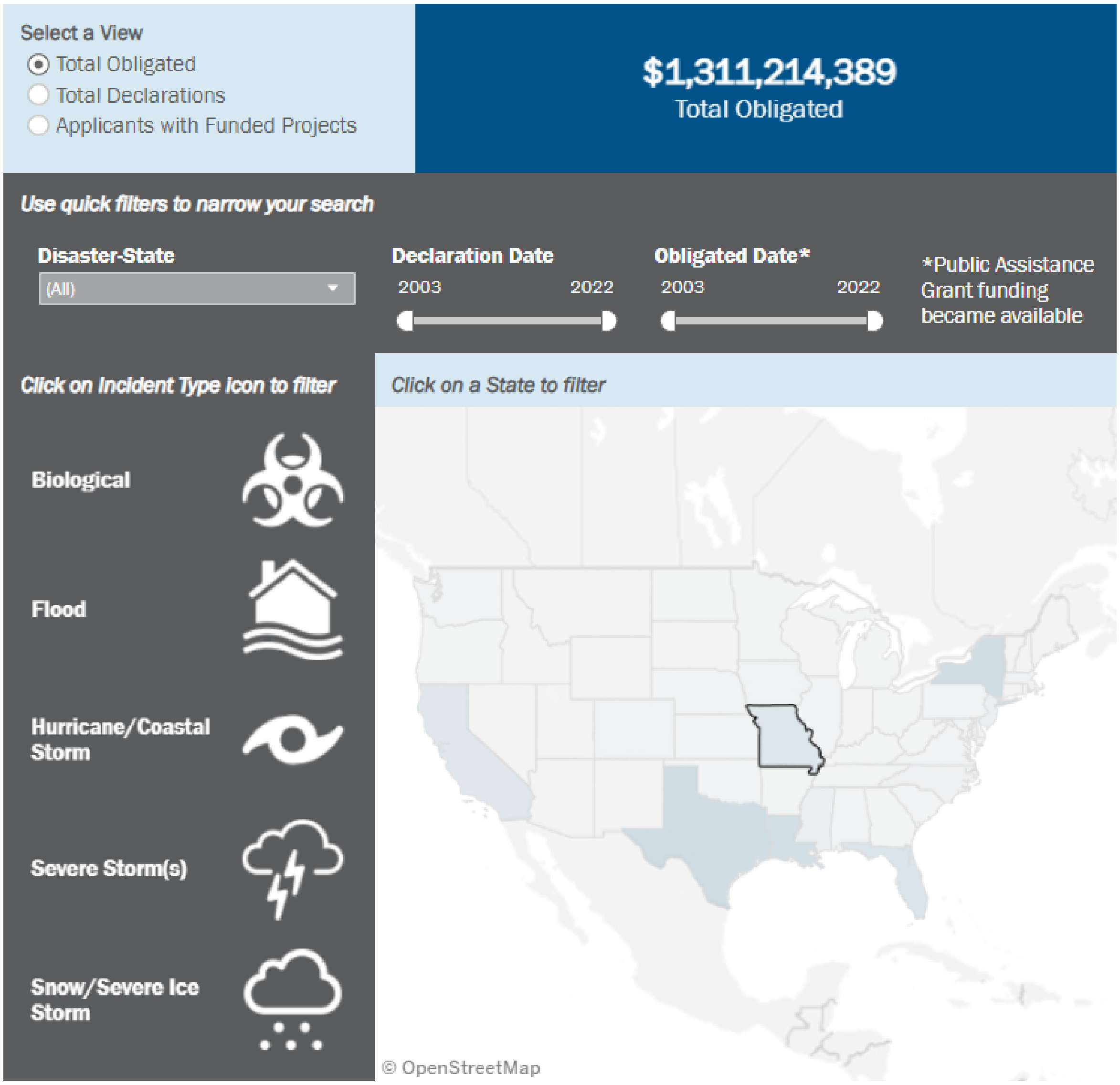


Table 3.17. Individual Assistance, Public Assistance and Mitigation Funding in Missouri, 2005-2022

Row Labels	Individual Assistance	Public Assistance	Hazard Mitigation Grant Program	Flood Mitigation Assistance	Repetitive Flood Claims Grant Program	Severe Repetitive Loss Grant Program	Grand Total
FY 2005	--	$1,751,641	--	$419,200	--	--	$2,170,841
FY 2006	$4,199,351	$31,993,551	$5,385,705	$300,290	--	--	$41,878,898
FY 2007	$2,428,002	$123,925,844	$25,448,443	--	--	--	$151,802,289
FY 2008	$20,934,138	$91,094,449	$22,586,693	--	$675	$172,423	$134,788,379
FY 2009	$12,287,808	$171,451,197	$45,510,391	$94,511	$1,336,716	--	$230,680,623
FY 2010	--	$17,450,778	$2,099,104	--	--	--	$19,549,882
FY 2011	$40,262,163	$199,960,705	$137,011,998	--	--	--	$377,234,866
FY 2013	--	$27,574,621	$21,414,244	--	--	--	$48,988,865
FY 2014	--	--	--	$215,600	--	--	$215,600
FY 2015	--	$55,453,106	$25,262,506	$895,632	--	--	$81,611,244
FY 2016	$13,088,319	$35,288,544	$97,924	$164,700	--	--	$48,639,487
FY 2017	$12,527,583	$83,150,578	$19,938,462	$1,228,611	--	--	$116,845,234
FY 2018	--	--	--	$948,658	--	--	$948,658
FY 2019	$7,477,718	$106,843,331	$35,726,537	$633,443	--	--	$150,681,029
FY 2020	$59,362,790	$494,696,305	$2,172,448	--	--	--	$556,231,543
FY 2021	--	$6,488,936	--	--	--	--	$6,488,936
FY 2022	$29,322,805	$2,534,501	--	--	--	--	$31,857,306
Total	**$201,890,677**	**$1,449,658,087**	**$342,654,455**	**$4,900,645**	**$1,337,391**	**$172,423**	**$2,000,613,680**

Source: Federal Emergency Management Agency, https://www.fema.gov/media-library/assets/documents/106308; https://www.fema.gov/data-visualizations/hazard-mitigation-assistance-obligations

3.3. Hazard Profiles and State Risk Assessment

Requirement §201.4(c)(2)(i): [The state risk assessment shall include an overview of the] location of all natural hazards that can affect the state, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate.

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii): The state risk assessment shall include an] overview and analysis of the state's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The state shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events.

[The state risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment.

Requirement for Update §201.4(d): Plan must be reviewed and revised to reflect changes in development.

Organization of the Hazard Profiles and State Risk Assessment

This Risk Assessment assesses various risks facing the State and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison. The evaluation involves many interrelated variables (toxicity, demographics, topography, etc.) and should be used by state and local officials in planning and prioritizing allocation of resources.

The Hazard Profiles and State Risk Assessment Section is organized by hazard type as follows:

- Natural Flood-Related Hazards
  - Flooding
  - Levee Failure
  - Dam Failure
- Natural Geologic Hazards
  - Earthquake
  - Land Subsidence / Sinkholes
- Natural Meteorological Hazards
  - Drought
  - Extreme Temperature
  - Severe Thunderstorms
  - Severe Winter Weather
  - Tornadoes
- Natural Other Hazard
  - Wildfire
- Human-Caused / Technological Hazards
  - Civil Disorder
  - Cyber Disruption
  - Environmental Health Emergencies
  - Fires (Urban/Structural)
  - Hazardous Materials
  - Mass Transportation Accidents
  - Nuclear Power Plants
  - Public Health Emergencies
  - Special Events
  - Terrorism
  - Utilities (Interruptions and System Failures)

Within each hazard section, the following sub-sections are included for each hazard:

- Description/Location
- Extent
- Previous Occurrences
- Probability of Future Hazard Events
- Changing Future Conditions Considerations
- State Vulnerability Overview
- State Estimates of Potential Losses
- Hazard Impact on Future Growth and Development
- EMAP Risk/Vulnerability/Consequence Analysis
- Risk Summary

Description/Location

This section consists of a general description of the hazard and the types of impacts it may have as well as the geographic location of the hazard in the planning area. Where available, maps are utilized to indicate the specific locations of the planning area that are vulnerable to the subject hazard.

Extent

This section will provide details on the strength or magnitude of the hazard.

Previous Occurrences

This section includes information on historic incidents and their impacts. Documentation of previous occurrences is sourced from available data repositories for each hazard. The National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) is the source for the historical hazard events for many of the meteorological hazards profiled in this Plan. While information contained in NCEI's Storm Events Database is generally the best, and sometimes the only, data available, the following disclaimer should be noted:

Some information appearing in Storm Data may be provided by or gathered from sources outside the National Weather Service (NWS), such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. An effort is made to use the best available information, but because of time and resource constraints, information from these sources may be unverified by the NWS. Accordingly, the NWS does not guarantee the accuracy or validity of the information. Other data limitations to note include the following: data collecting for some hazards did not begin until 1993, damages reported are purely estimates based on the reporting entity and damages reported are area-wide and not specific to the location.

Probability of Future Hazard Events

The frequency of past events is one of the elements used to gauge the likelihood of future occurrences. Where possible, the probability or chance of occurrence was calculated based on historical data. Probability was determined by dividing the number of events observed by the number of years and multiplying by 100. This gives the percent chance of the event happening in any given year. An example would be three droughts occurring over a 30-year period, which suggests a 10 percent chance of a drought occurring in any given year.

Changing Future Conditions Considerations

This section will include a summary of climate change impacts that may impact future hazard events including changes in the probability, location, impacts and extent. Although past occurrences are one important element of a factual basis of hazard risk, the challenges posed by climate change, such as more intense storms, frequent heavy precipitation, heat waves, drought and extreme flooding could significantly alter the types and magnitudes of hazards impacting the State in the future.

Vulnerability Overview and State Estimates of Potential Loss

The Vulnerability Overview will provide an overview and analysis of the State's *vulnerability* to the hazards which will serve to describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. The overview vulnerability analysis was completed using a variety of methods, including, HAZUS, other GIS-based risk modeling, statistical analysis of exposure, census data and past historic losses.

Where data is available, the State Estimates of Potential Loss Section will provide the results of analysis of *potential losses* to the identified vulnerable structures utilizing a combination of HAZUS, other GIS-based risk modeling, statistical analysis of past historic losses and hypothetical scenario-based estimates. The methods utilized are described in greater detail for each hazard where data is available. For those hazards for which data is not available, the limitations which preclude analysis of potential losses will be described.

Table 3.18. Summary of Vulnerability Analysis/Loss Estimation Updates

Hazard	2018 Vulnerability Analysis/Loss Estimation Summary	2023 Vulnerability Analysis/Loss Estimation Summary
Natural Flood Related Hazards		
Flooding	HAZUS MH 4.0 - 1% Annual Chance flood loss scenario. All counties were updated utilizing the newly released version of HAZUS. For counties which have RiskMAP products available, the depth grids for those communities were utilized as part of the HAZUS analysis. For counties with new floodplains developed since 2010 for which there are no RiskMAP products, depth grids were created utilizing the updated DFIRM data. The MSDIS structure inventory was used to supplement HAZUS as the source for numbers and types of at-risk structures.	Hazus 6.0 - 1% Annual Chance flood loss scenario. All counties were updated utilizing the newly released version of HAZUS. Updated Census data utilized. RiskMAP depth grids were utilized as part of the HAZUS analysis for 114 Counties. For one county, depths grids were created from DFIRM data. The MSDIS structure inventory (77 Counties) and building footprints (39 Counties and City of St. Louis) was used to supplement HAZUS as the source for numbers and types of at-risk structures.
Levee Failure	GIS analysis of levee protected areas in National Flood Hazard Layer and National Levee Database against HAZUS/MSDIS exposure data for values, numbers, and types of structures at risk. Estimated population at risk based on number of residential properties in protected areas times average household size.	GIS analysis of levee protected areas in National Flood Hazard Layer and National Levee Database against HAZUS/MSDIS exposure data for values, numbers, and types of structures at risk. Estimated population at risk based on number of residential properties in protected areas times average household size. Updated Census data utilized.
Dam Failure	GIS analysis of Inundation maps against HAZUS/MSDIS exposure data -State-regulated High Hazard dams -Federal dams to determine types, numbers and values of buildings at risk	GIS analysis of Inundation maps against HAZUS/MSDIS exposure data -State-regulated High Hazard dams -Federal dams to determine types, numbers and values of buildings at risk

Hazard	2018 Vulnerability Analysis/Loss Estimation Summary	2023 Vulnerability Analysis/Loss Estimation Summary
	estimated population at risk based on number of residential properties in inundation areas times average household size.	estimated population at risk based on number of residential properties in inundation areas times average household size.
Natural Geologic Hazards		
Earthquake	HAZUS MH 4.0 - 2% annual chance in 50 years probabilistic scenario. This analysis was also supplemented with additional funding provided by CUSEC to further analyze additional facilities at risk including: bridges, chemical facilities, fire stations, schools and medical facilities.	Hazus 6.0 - 2% annual chance in 50 years probabilistic scenario. Updated Census data utilized.
Land Subsidence / Sinkholes	The sinkhole hazard layer was used in conjunction with the MSDIS structure file and potentially layers locating specific infrastructure, to determine structures that fall within sinkhole areas as well as structures that are within a buffered distance of sinkholes. The number of mines and caves per county was reported through data presentation as available from the Department of Natural Resources.	The sinkhole area hazard layer was used in conjunction with the MSDIS structure file and building footprints, where available, to determine structures that fall within sinkhole areas as well as structures that are within a buffered distance of sinkholes. The number of mines per county and caves per USGS quadrangle were reported through data presentation as available from the Department of Natural Resources.
Natural Meteorological Hazards		
Drought	Updated statistical analysis utilizing the following factors: 1. # of Average Annual Drought Impacts (Drought Impact Reporter) 2. Crop Exposure (2012 USDA Census of Agriculture 3. Annualized Crop Claims (USDA RMA 2007-2016) 4. SOVI (University of South Carolina)	Updated statistical analysis utilizing the following factors: 1. # of Average Annual Drought Impacts (Drought Impact Reporter) 2. Crop Exposure (2017 USDA Census of Agriculture) 3. Annualized Crop Claims (USDA RMA 2012-2021) 4. SOVI (University of South Carolina)
Extreme Temperature	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / years 1993-2016) 2. SOVI (University of South Carolina) 3. Population (2015 ACS) 4. % population age 65 and up (2015 ACS)	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / years 1993-2021) 2. SOVI (University of South Carolina) 3. Population (CO-EST2019-CUMCHG-29) 4. % population age 65 and up (CO-EST2019-CUMCHG-29)
Severe Thunderstorms	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS)-hail, wind, and lightning 4. SOVI 5. Housing Density (2015 ACS) 6. # Mobiles Homes (2010 Census)	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS)-hail, wind, and lightning 4. SOVI 5. Housing Density (CO-EST2019-ANNHU-29) 6. # Mobiles Homes (ACSST5Y2019.S2504)

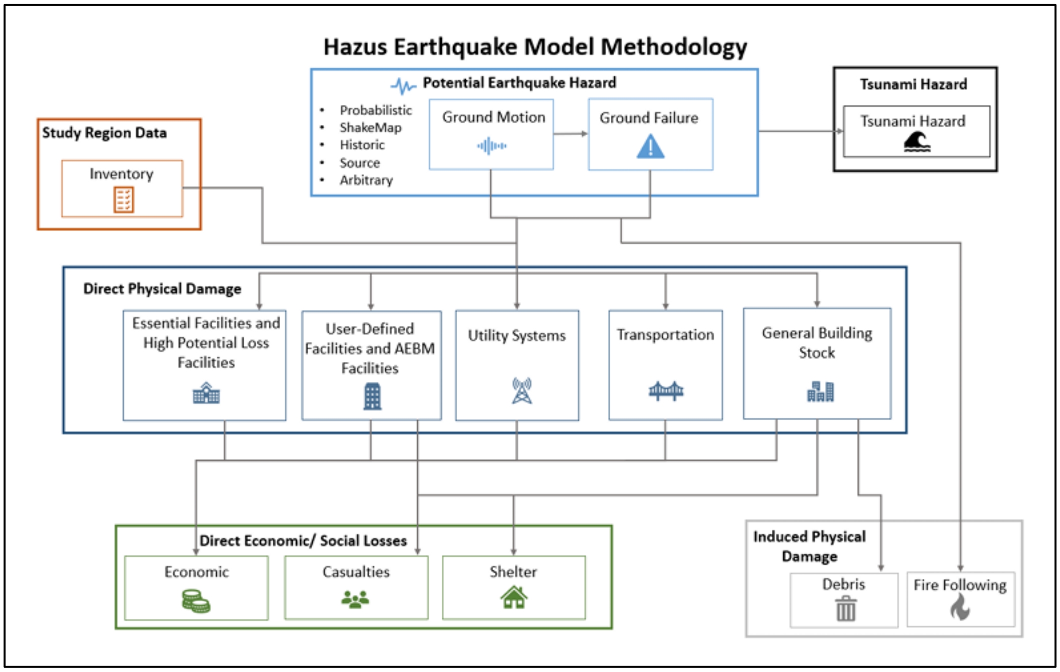
Hazard	2018 Vulnerability Analysis/Loss Estimation Summary	2023 Vulnerability Analysis/Loss Estimation Summary
Severe Winter Weather	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS) 4. SOVI (University of South Carolina) 5. Housing Density (2015 ACS)	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS) 4. SOVI (University of South Carolina) 5. Housing Density (CO-EST2019-ANNHU-29)
Tornadoes	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS) 4. SOVI 5. Population Density (2015 ACS) 6. # Mobile Homes	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS) 4. SOVI 5. Population Density (CO-EST2019-CUMCHG-29) 6. # Mobile Homes
Natural Other Hazard		
Wildfire	GIS layers available from SILVIS Lab at University of Wisconsin - Madison were utilized to quantify the population and buildings at risk within wildfire risk zones	GIS layers available from SILVIS Lab at University of Wisconsin - Madison were utilized to quantify the population and buildings at risk within wildfire risk zones
Human-Caused / Technological Hazards		
CBRNE Attack	EMCAPS scenarios for 1. Chemical 2. Biological 3. IED-ammonium nitrate 4. Radiological IED	Combined with Terrorism Hazard
Civil Disorder	Data presentation of past civil disorder events to provide a basis for potential future event	Data presentation of past civil disorder events to provide a basis for potential future event
Cyber Disruption	Data presentation of known cyber disruption events to provide a basis for potential future events	Data presentation of known cyber disruption events to provide a basis for potential future events
Environmental Health Emergency	Previously included with Public Health Emergency	Data Presentation and narrative description focusing on the following public health considerations 1. Air Pollution 2. Water Pollution
Fires (Urban/Structural)	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence-structure fire (NFIRS) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NFIRS) 4. Housing Density (2015 ACS) 5. # of Deaths / Injuries (NFIRS) 6. SOVI	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence-structure fire (NFIRS) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NFIRS) 4. Housing Density (CO-EST2019-ANNHU-29) 5. # of Deaths / Injuries (NFIRS) 6. SOVI
Hazardous Materials	Data Presentation and narrative description including updates of Hazardous Materials Incidents reported to the Missouri	Data Presentation and narrative description including updates of Hazardous Materials Incidents reported to the Missouri Environmental Emergency Response Tracking System (MEERTS).

Hazard	2018 Vulnerability Analysis/Loss Estimation Summary	2023 Vulnerability Analysis/Loss Estimation Summary
	Environmental Emergency Response Tracking System (MEERTS).	
Mass Transportation Accidents	Data Presentation and narrative description	Data Presentation and narrative description
Nuclear Power Plants	Data Presentation and narrative description	Data Presentation and narrative description
Public Health Emergencies / Environmental Issues	Data Presentation and narrative description focusing on the following public health considerations 1. Pandemic Influenza 2. Smallpox 3. St. Louis Encephalitis 4. Meningitis 5. Lyme Disease 6. West Nile Virus 7. SARS 8. Zika Virus 9. Ebola Virus 10. Tuberculosis 11. Air Pollution 12. Water Pollution	Narrative description focusing on the following public health considerations 1. Pandemic Influenza 2. Smallpox 3. St. Louis Encephalitis 4. Meningitis 5. Lyme Disease 6. West Nile Virus 7. SARS 8. Zika Virus 9. Ebola Virus 10. Tuberculosis Data presentation focusing on impacts of COVID-19 pandemic.
Special Events	EMCAPS scenario for IED - ammonium nitrate fuel oil in crowded stadium	EMCAPS scenario for IED - ammonium nitrate fuel oil in crowded stadium
Terrorism	EMCAPS scenario for Chemical Attack - mustard gas in crowded stadium	EMCAPS scenarios for 1. Chemical 2. Biological 3. IED-ammonium nitrate 4. Radiological IED
Utilities (Interruptions and System Failures)	Descriptions along with the presentation of data on causes of utility interruptions and system failures including the following: • Electrical power • Natural gas • Public water (potable and wastewater treatment) • Communications systems Causes of utility interruption discussed include: • Cascading impacts of other primary hazards (thunderstorm, winter storm, flooding, tornado, cyber disruption, terrorism, etc.) • Space Weather / geomagnetic storms • Lack of Maintenance • Human Error • System Overload / Failure	Descriptions along with the presentation of data on causes of utility interruptions and system failures including the following: • Electrical power • Natural gas • Public water (potable and wastewater treatment) • Communications systems Causes of utility interruption discussed include: • Cascading impacts of other primary hazards (thunderstorm, winter storm, flooding, tornado, cyber disruption, terrorism, etc.) • Space Weather / geomagnetic storms • Lack of Maintenance • Human Error • System Overload / Failure

HAZUS and Other GIS-Based Loss Estimation Methodology

Hazus is FEMA's standardized loss-estimation software program built upon an integrated geographic information system platform (see **Figure 3.14**). The Hazus risk assessment methodology is parametric in that distinct hazard, vulnerability, and inventory parameters (earthquake spectral ordinates, building construction, and building classes) were modeled using the Hazus software to determine the impact on the built environment (damage and losses). This risk assessment applied Hazus to produce regional profiles and estimate losses for two hazards: earthquakes and riverine flooding.

Figure 3.14. Conceptual Model of Hazus Earthquake Methodology



Source: Hazus Earthquake Model User Guidance, Hazus 5.1, April 2022

For some hazards, such as dam failure, levee failure, land subsidence and wildfire, geographic locations of areas at risk to the hazard are known. However, these hazards are outside the scope of Hazus. For these hazards, the known locations of areas at risk are mapped utilizing geographic information systems to show areas of the State that are at greatest risk.

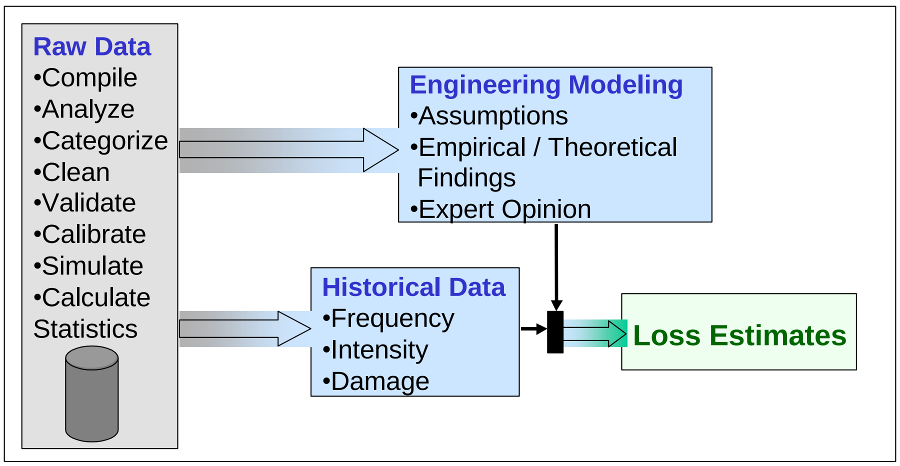
Statistical Risk Assessment Methodology

The statistical risk assessment methodology was applied to analyze hazards of concern that are outside the scope of Hazus or other GIS-based risk-modeling. This approach is based on different principals than Hazus and does not rely on readily available automated software. It uses a statistical approach and mathematical modeling of risk to predict a hazard's frequency of occurrence and estimated impacts based on recorded or historic damage information. Historical data for each hazard are used and statistical evaluations are performed using manual calculations. **Figure 3.15** illustrates a conceptual model of the statistical risk assessment methodology. The general steps used in the statistical risk assessment methodology are summarized below:

- Compile data from national and local sources
- Conduct statistical analysis of data to relate historical patterns within data to existing hazard models (minimum, maximum, average and standard deviation)

➢ Categorize hazard parameters for each hazard to be modeled
➢ Develop model parameters based on analysis of data, existing hazard models and risk engineering judgment
➢ Apply hazard model including:
    - Analysis of frequency of hazard occurrence
    - Analysis of intensity and damage parameters of hazard occurrence
    - Development of intensity and frequency tables and curves based on observed data
    - Development of simple damage function to relate hazard intensity to a level of damage (e.g., one flood = $ in estimated damage)
    - Where applicable, development of exceedance and frequency curves relating a level of damage for each hazard to an annual probability of occurrence
    - Development of annualized loss estimates

Figure 3.15. Conceptual Model of the Statistical Risk Assessment Methodology



Hypothetical Scenario-based Estimates

Specific scenario-based loss estimates are provided for several of the manmade and other hazards of concern that are outside the scope of Hazus, GIS-based risk-modeling and statistical analysis. For these hazards information on historical losses was not available. In addition, since there are so many variables involved with manmade hazards, it is difficult to make generalized assumptions for future events. In these instances, the planning team chose to analyze specific scenarios to establish an acceptable loss estimation methodology.

Economic Impact

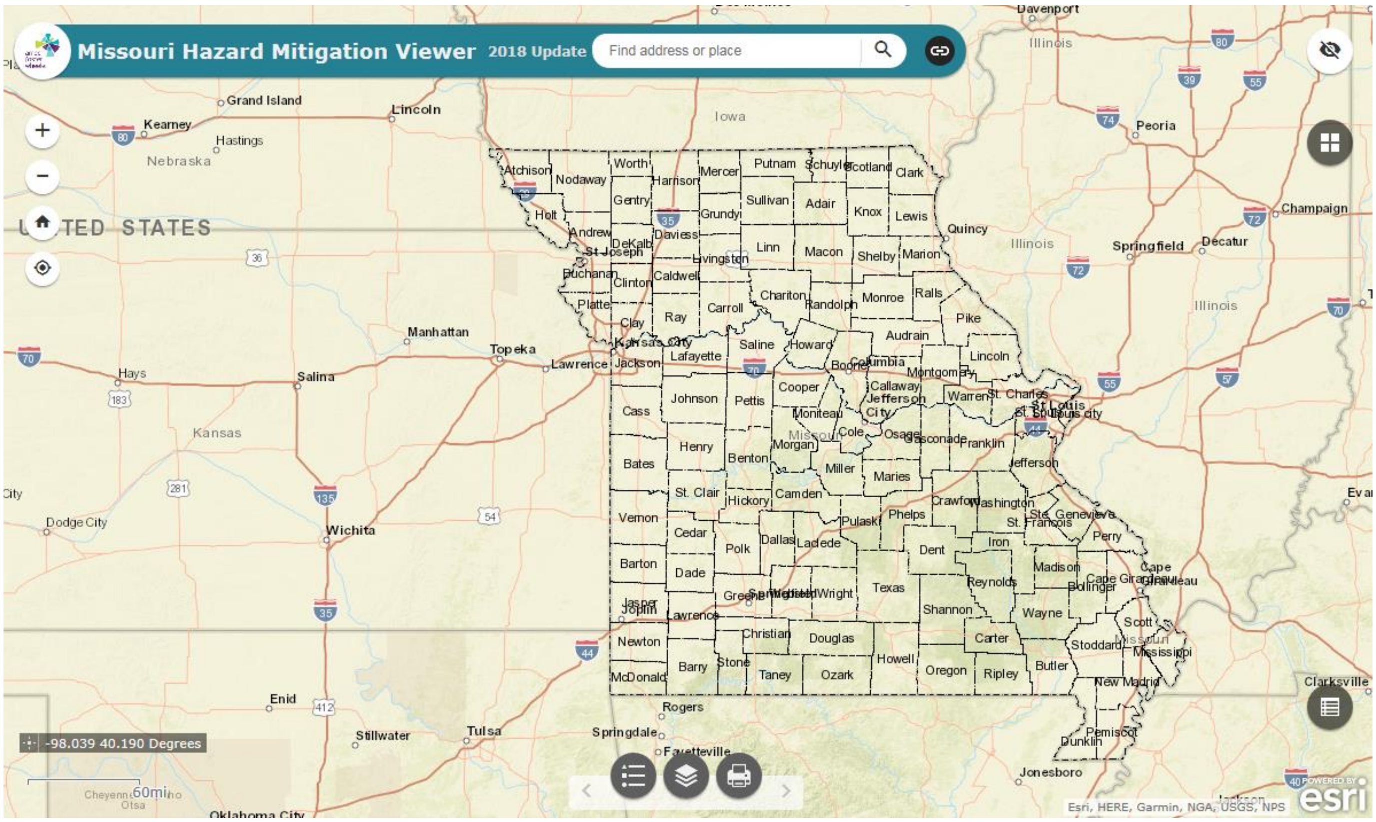
Risk assessment is presented for annualized losses, whenever possible. In general, presenting results in the annualized form is very useful for three reasons: 1) Contribution of potential losses from all (long term) future disasters is accounted for with this approach; 2) Results in this form for different hazards are readily comparable and hence easier to rank; and 3) When evaluating mitigation alternatives, use of annualized losses is an objective approach.

Where possible, the economic loss results are presented according to annualized loss. The estimated annualized loss addresses key components of risk: the probability of a hazard event occurring in the study area, the consequences of the event (largely a function of building construction type and quality), and the intensity of the event. By annualizing estimated losses, this factors in historic patterns of frequent small events with infrequent larger events to provide a balanced presentation of the risk. In Hazus, losses are annualized for earthquake return periods of 100, 250, 500, 750, 1,000, 1,500, 2000 and 2,500 years.

Missouri Hazard Mitigation Viewer

With the 2023 Plan Update, SEMA is pleased to continue to provide online access to all of the risk assessment data and associated mapping for all 114 counties in the State, including the independent City of St. Louis. Through a web-based Missouri Hazard Mitigation Viewer (see **Figure 3.16**), local planners or other interested parties can obtain all State Plan datasets. This effort removes a barrier for local mitigation planners to performing all the needed local risk assessments by providing the data developed during the 2023 State Plan Update.

Figure 3.16. Missouri Hazard Mitigation Viewer



Functionality will combine all data layers developed or provided by SEMA planners and partners (State and Local) into one central location. The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2023 State Plan for easy reference, search and query capabilities, zoom levels to county level data and capable of downloadable PDF format maps.

The Missouri Hazard Mitigation Viewer can be accessed here: http://bit.ly/MoHazardMitigationPlanViewer2023. A Users Guide for the web-based Viewer is provided in **Appendix B**.

Hazard Impact on Future Growth and Development

Where applicable, changes in development will be discussed as they pertain to identified hazard-prone areas.

Risk Summary

This Risk Assessment assesses various risks facing the State and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison. The evaluation involves many interrelated variables (toxicity, demographics, topography, etc.) and should be used by state and local officials in planning and prioritizing allocation of resources.

The following definitions explain the probability and severity ratings for each hazard:

Probability—The likelihood that the hazard will occur. Based on available data, probability was determined for each hazard by either a statistical analysis of historical occurrences or a statistical model of probable occurrence. In addition, input from the SRMT was considered in the probability determination process.

Severity—The deaths, injuries, or damage (property or environmental) that could result from the hazard.

- **Low**—Few or minor damage or injuries are likely.
- **Moderate**—Injuries to persons and damage to property and the environment is expected.
- **High**—Deaths and major injuries and damage will likely occur.

The hazards covered in the risk assessment, along with the probability and severity ratings that were determined from the updated risk assessment are provided in **Table 3.19.**

Table 3.19. Probability/Severity Rating Summary

Natural Hazards	Probability	Severity
Natural Flood-Related Hazards		
Flooding (Riverine & Flash)	100%	High
Levee Failure	100%	Moderate
Dam Failure	45%	Moderate
Natural Geologic Hazards		
Earthquake	72%	High
Land Subsidence/Sinkholes	100%	Low
Natural Meteorological Hazards		
Drought	6-11%	High
Extreme Temperature	100%	Moderate
Severe Thunderstorms	100%	Moderate
Severe Winter Weather	100%	Moderate
Tornadoes	100%	High
Natural Other Hazard		
Wildfire	100%	Low to Moderate
Human-caused/Technological Hazards		
Civil Disorder	<1%	Low to High
Cyber Disruption	<1%	Low to High
Environmental Health Emergencies	<1%	Low to High

Natural Hazards	Probability	Severity
Structural and Urban Fires	100%	Moderate
Hazardous Materials	100%	Moderate
Mass Transportation	100%	Moderate
Nuclear Power Plants	<1%	Low to High
Public Health Emergencies	<1%	Low to High
Special Events	<1%	Low to High
Terrorism	<1%	Low to High
Utilities (Interruptions and System Failures)	100%	Low

Emergency Management Accreditation Program (EMAP)

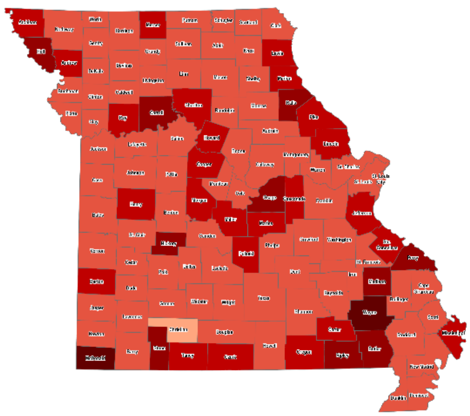
The Emergency Management Accreditation Program (EMAP) is an independent organization that applies a standards-based voluntary assessment and peer review accreditation process for government programs responsible for coordinating prevention, mitigation, preparedness, response, and recovery activities for natural and human caused disasters. As part of the State of Missouri EMAP accreditation process, an analysis of the potential for detrimental impacts of hazards was conducted and integrated into the Plan. The EMAP analysis, in **Appendix C**, contains a summary of risk and vulnerability assessments, a succinct consequence analysis, and an overall risk and consequence score for each hazard addressed in the plan.

3.3.1. Flooding

Description

A flood is the partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur as a result of dams being breached or overtopped.

Vulnerability



Extent/Range of Intensity

Flood severity categories, as defined by the National Weather Service, describe the severity of flood impacts in the corresponding river reach. The first three of these flood categories—minor, moderate, and major flooding—are bounded by an upper and lower flood stage, with flood stage defined as an established gage height for a given location at which a rise in water surface level begins to create a hazard to lives, property, or commerce.

Probability	Severity	Location
94% 44 Disaster Declarations in 47 years	High	Statewide

State Vulnerability Overview

For the 2023 State Plan Update, SEMA used the most recent release of Hazus, version 6.0, to model flood vulnerability and estimate flood losses for all 114 counties and the City of St. Louis due to depth of flooding.

Changing Future Conditions Considerations

The expected increases in rainfall frequency and intensity are likely to put additional stress on natural hydrological systems and community stormwater systems. Heavier snowfalls in the winter will lead to intensified spring flooding, and groundwater levels will remain high even in non-floodplain areas. Such changes in climate patterns can lead to the development of compounding events that interact to create extreme conditions. Flooding caused by high groundwater levels typically recedes more slowly than riverine flooding, slowing the response and recovery process. Groundwater-fed rivers and streams are also likely to experience heightened flooding when groundwater levels are high.

Risk Summary/Problem Statement

Using the indicators of Building Loss, Lost Ratio and Displaced Persons and the top ten counties with the highest risk for these indicators, the data suggests that it would be most feasible to spend effort and dollars on mitigating losses in these top ten locations. Boone, Butler, Clay, Jackson, Jefferson, McDonald, St. Charles, and St. Louis Counties have the highest risk for all 3 of these indicators and are the most vulnerable to the 100-year flood. Clay and Jackson Counties are split by the Missouri River and are heavily populated with Kansas City metropolitan communities. St. Charles and St. Louis Counties are also split by the Missouri River; they are heavily populated with St. Louis City metropolitan communities. Boone and Jefferson Counties border the Missouri River. McDonald County is located in the southwestern corner of the state and is subject to flooding from the Elk River. Mitigation efforts such as buyouts, floodproofing and insurance awareness, implementation of higher regulatory standards, adoption of building codes, participation in the CRS Program, and pre-staging of emergency response resources to reduces losses would be most beneficial to these counties.

Description/Location

A flood is the partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur as a result of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event.

The areas adjacent to rivers and stream banks that carry excess floodwater during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat area adjoining a river or stream. The terms “base flood” and “100-year flood” refer to the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year, based on historical records. Floodplains are a vital part of a larger entity called a basin, which is defined as all the land drained by a river and its branches.

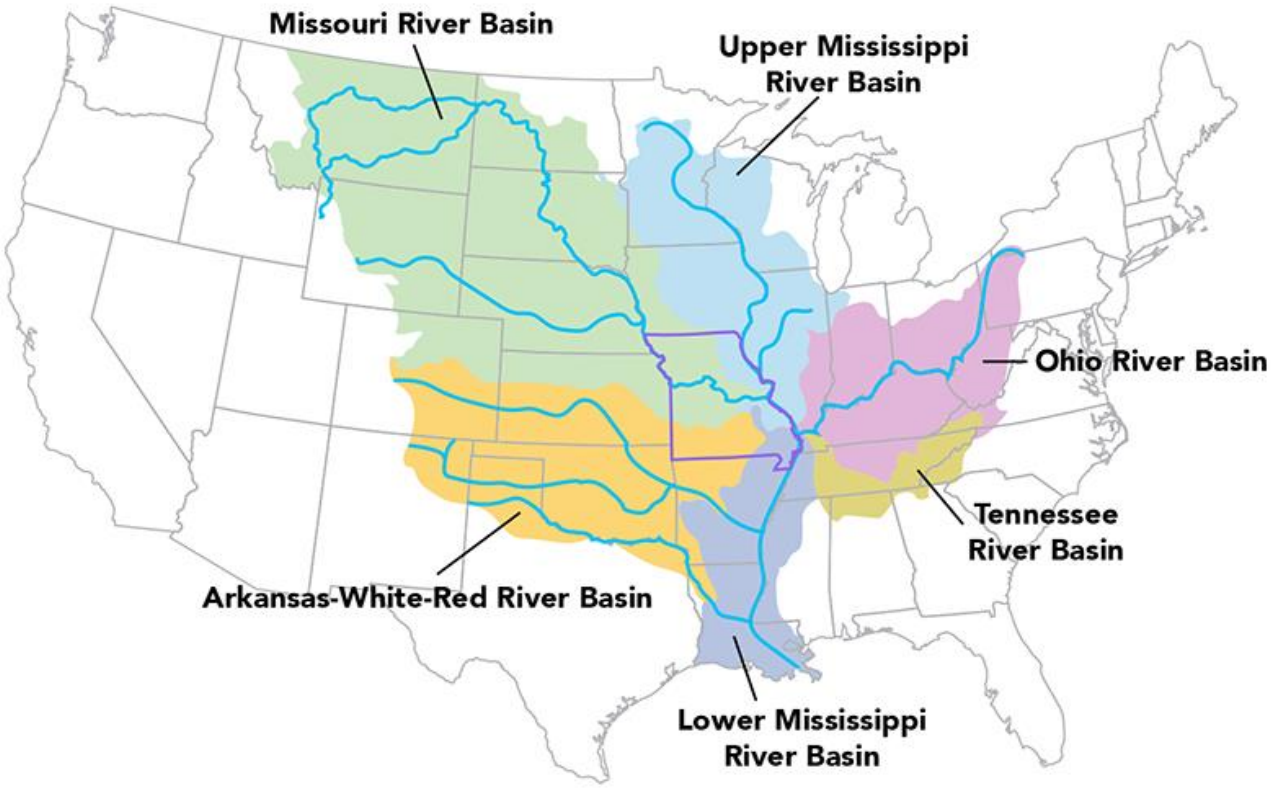
Figure 3.17. Mississippi River flooding along the St. Louis River Front, June 2019

Source: NWS St. Louis, https://twitter.com/NWSStLouis/status/1137037903953944576/photo/2

The land that forms the State of Missouri is contained within the Mississippi, Missouri, and Arkansas-White-Red River Basins (see **Figure 3.18**). The Mississippi River Basin drains the eastern part of the State, the Missouri River Basin drains most of the northern and central part of the State, the White River Basin drains the south-central part of the State, and the Arkansas River Basin drains the southwest part of the State. The Missouri River Basin drains over half the State. When the Missouri River joins the Mississippi River at St.

Louis, it becomes part of the Mississippi River Basin, which is the largest basin in terms of volume of water drained on the North American continent.

Figure 3.18. River Basins within Missouri



Source: MoDNR

In some cases, flooding may not be directly attributable to a river, stream, or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations–areas that are often not in a floodplain. This type of flooding, often referred to as sheet flooding, is becoming increasingly prevalent as development outstrips the ability of the drainage infrastructure to properly carry and disperse the water flow. Flooding also occurs due to combined storm and sanitary sewers that cannot handle the tremendous flow of water that often accompanies storm events. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns. Unfortunately, this damage caused by sewer back-up is not covered under the NFIP. Damage should be addressed through the installation of backflow prevention/check valve devices, and the application of building codes.

Extent

Flood severity categories, as defined by the National Weather Service, describe the severity of flood impacts in the corresponding river reach. The first three of these flood categories—minor, moderate, and major flooding—are bounded by an upper and lower flood stage, with flood stage defined as an established gage height for a given location at which a rise in water surface level begins to create a hazard to lives, property, or commerce.

The severity of flooding at a given stage is not necessarily the same at all locations along a river reach due to varying channel and bank characteristics or the presence of levees. Therefore, the upper and lower stages for

a given flood category are usually associated with water levels corresponding to the most significant flood impacts somewhere in the reach.

The flood severity categories are defined as:

- Minor Flooding - minimal or no property damage, but possibly some public threat (e.g., inundation of roads)
- Moderate Flooding - some inundation of structures and roads near stream, evacuations of people and/or transfer of property to higher elevations
- Major Flooding - extensive inundation of structures and roads, significant evacuations of people and/or transfer of property to higher elevations
- Record Flooding - flooding which equals or exceeds the highest stage or discharge observed at a given site during the period of record. The highest stage on record is not necessarily above the other three flood categories – it may be within any of them or even less than the lowest, particularly if the period of record is short (e.g., a few years)

The NWS has also defined three response levels for alerting the public as to the danger of floods, as described in **Table 3.20**.

Table 3.20. National Weather Service Flood Response Levels/Activities

Alert Level	Definition
Flood Watch	A Flood Watch is issued when conditions are favorable for a specific hazardous weather event to occur. A Flood Watch is issued when conditions are favorable for flooding. It does not mean flooding will occur, but it is possible.
Flood Advisory	A Flood Advisory is issued when a specific weather event that is forecast to occur may become a nuisance. A Flood Advisory is issued when flooding is not expected to be bad enough to issue a warning. However, it may cause significant inconvenience, and if caution is not exercised, it could lead to situations that may threaten life and/or property.
Flood Warning	A Flood Warning is issued when the hazardous weather event is imminent or already happening. A Flood Warning is issued when flooding is imminent or occurring.
Flash Flood Warning	A Flash Flood Warning is issued when a flash flood is imminent or occurring. If you are in a flood prone area move immediately to high ground. A flash flood is a sudden violent flood that can take from minutes to hours to develop. It is even possible to experience a flash flood in areas not immediately receiving rain.

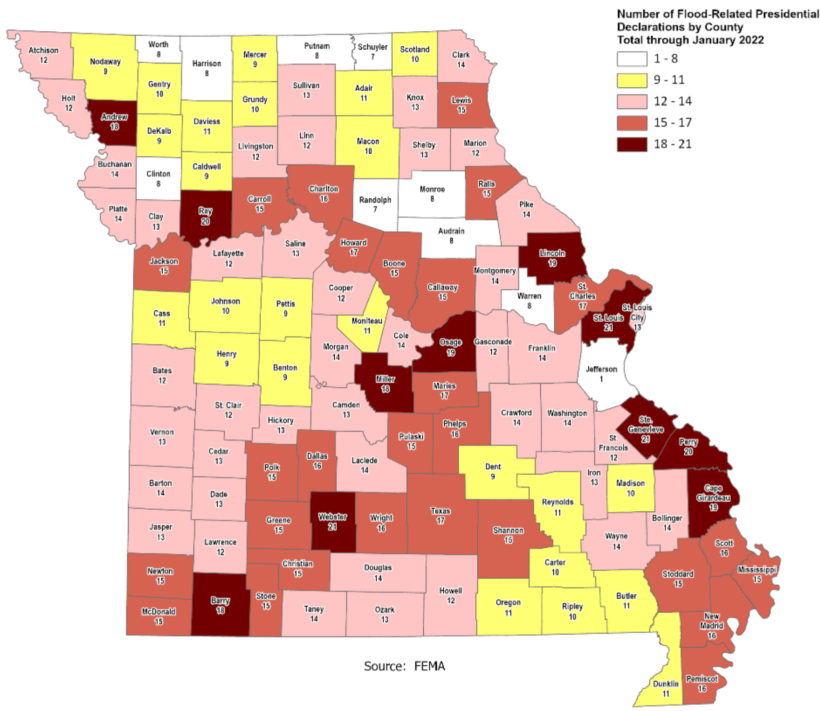
Source: National Weather Service

Previous Occurrences

Missouri has a long history of extensive flooding over the past century. Scores of river communities, including those along the Mississippi and Missouri rivers, have become quite skilled and experienced in flood-fighting efforts due to frequent instances of severe flooding in recent years. Flooding along Missouri's major rivers generally results in slow moving disasters. River crest levels are forecast several days in advance, allowing communities downstream sufficient time to take protective actions, such as sandbagging and evacuations. Nevertheless, these flood disasters exact a heavy toll in terms of human suffering and extensive losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

Floods are the most common natural disaster in the United States. The State of Missouri has had more than 50 flood-related disaster declarations since 1976, of which, all the counties within the state have been affected to some degree (see **Figure 3.19**). Certain parts of the State have been moderately affected by flooding, i.e. Randolph, Schuyler, Audrain, Clinton, Harrison, Monroe, Putnam, Warren, and Worth Counties with less than 8 flood-related disaster declarations. Other parts have been severely affected, i.e. Jefferson, Perry, Ray, St. Louis, Ste. Genevieve, and Webster with over 20 flood related disaster declarations each. The figure below helps to identify the areas of the State where counties have had numerous declarations and, as such, demonstrate a high risk of repeated flooding. **Table 3.16** in **Section 3.2.3** provides details on the Presidential Disaster Declarations in Missouri that included floods or flooding from 1975 to the present.

Figure 3.19. Number of Flood-Related Presidential Declarations by County



While most of the flooding in the State has been related to the Missouri River to some extent, this is not always the case. **Figure 3.20** depicts the extent of flooding throughout the state during the 1993 floods. Some areas have more detail due to studies done on those watersheds. By comparing this figure to **Figure 3.19**, showing the number of disaster declarations per county, one could form a clearer understanding of the flooding risk and potential for flood loss within the state.

Ranking among the State's most notable flood disasters are the Missouri River flood of 1927, which spread destruction across 17 million acres, and the flood of 1951, which caused an estimated $400 million in damage. Record flooding also occurred in 1973 along the Mississippi River, where backwater inundated 474,000 acres at a loss of $40 million. The unseasonably heavy rainfall produced severe headwater flooding along many of the area’s tributary streams, particularly in the St. John's Basin in Missouri and along the St. Francis and White Rivers in Arkansas. Of special historic interest is the December 1982 flood that spread dioxin-contaminated soil in the Times Beach area near St. Louis and led to a federal buyout of the entire town. In the fall of 1986, record flooding returned in Missouri, as well as in Michigan, Illinois, Kansas, and Oklahoma, with all these states declared federal disaster areas. Significant flooding next occurred in the State in the spring of 1990,

particularly along the Missouri River in western, central, and portions of eastern Missouri. Record-level, repetitive flooding occurred from 1993 through 1995, and flash flooding ravaged several areas of the State in July and October 1998. In the Spring of 1999 and 2000, flash flooding and severe storms again battered portions of the State. A significant flooding event in the spring of 2011, the Birds Point-New Madrid Area Flood, required the levees to be intentionally blown in order to relieve flood waters downstream.

Figure 3.20. Flooding Extent during the 1993 Floods

For 2013, there were 2 Presidential Declarations, DR-4130 July 18, 2013, affecting 28 counties spread across the state and DR-4144 September 6, 2013, affecting 18 counties focused in the south-central part of the State. 2014 brought a single Presidential Declaration, DR-4200 October 31, 2014, with 20 counties affected concentrated in the north-central part of the State. August 7, 2015, brought Presidential Declaration DR-4238 affecting 76 counties across the state.

The year 2016 was also a critical year for flooding in Missouri. With the 76 counties affected in August 2015 by DR-4238 still in recovery mode, another flooding event took place in late December centered along I-44 in Missouri were affected by flooding due to a relatively narrow band of storms that unusually heavy rainfall that averaged over 5 inches across the affected areas. Presidential Declaration DR-3374 was made on January 2, 2016. This disaster was followed on the heels by a rare December flooding in 2016, in which 52 counties were affected across the State. This second event was a Presidential Declared Disaster DR-4250 on

January 21, 2016. For many of these counties, this event became the new flood of record. In areas were mapping updates were underway, partnerships formed at an unprecedented rate between government agencies, including but not limited to USACE, USGS, NWS, NOAA, SEMA and MoDNR to include the new calculations in the flood risk analysis being performed.

In May 2017, 35 counties were designated in the Federal Disaster Declaration for the flooding that occurred from April 28 to May 11. $19 million was paid to policyholders before the federal disaster was declared. Over 25% of the NFIP claims filed addressed damage outside of the Special Flood Hazard Area. This flooding ranged from I-44 to the southern Stateline and resulted in levee breaches just across the Arkansas State line and numerous road overtopping. Almost 12 inches of precipitation was reported over the 10-day period in a series of events. April 2017 has preliminarily been ranked as the wettest April on record by NOAA.

In 2019, precipitation and flooding reached historic levels in the Missouri River Basin. DR-4435 and DR-4451. Starting in March with the "bomb cyclone" event, portions of the Missouri River and its tributaries were above flood stage for most of the year. Impacts from the heavy precipitation and subsequent flooding were widespread. Communities in Missouri and neighboring states were evacuated. Farmland was inundated. Critical infrastructure, such as roads, bridges, and levees, were damaged or destroyed.

A notable flash flood event occurred in July of 2022, DR-4665. A persistent series of thunderstorms developed in the evening of July 25th across east-central Missouri. The thunderstorms expanded in area, and by around 10pm were impacting the St. Louis metropolitan area. Rain continuously fell at St. Louis-Lambert International Airport from 11pm until 2pm on the 26th. During that time, rainfall rates exceeding 2 inches-per-hour were observed and 9.06 inches of rain fell in a 15-hour period. In one six-hour period, 7.68 inches of rain fell, which statistically has a 1 in 1000 chance of occurring in a given year. Despite dry conditions prior to the event, rainfall amounts, and rates of these magnitudes caused widespread impacts and at least one fatality.

Additional details for historical flood events are provided in the following paragraphs.

Floods of 1993–1995

The floods of 1993 through 1995 represent Missouri's worst repetitive flood events. Within this time frame, there were five presidential disaster declarations, including four in just one 12-month period. This period extended from May 11, 1993, when the first declaration was issued by President Clinton, through April 21, 1994, when the fourth declaration was approved. Flooding in the spring of 1995 resulted in a fifth disaster declaration, issued on June 2, 1995.

The ravages of these floods left a legacy of destruction, human suffering, and property damage of unprecedented terms in Missouri history. The fact that Missouri would need several years to recover from these repetitive flood disasters was undisputed.

In 1993 alone, a total of 112 of Missouri's 114 counties were included in at least one or more of the declarations. Only Cedar County in southwest Missouri and Dunklin County in the southeast portion of the State were not included in any of the 1993 declarations.

A number of flood-level records were broken in 1993 and, in the USACE St. Louis and Kansas City Districts, 867 of 947 federal and nonfederal levees failed or were overtopped and greatly contributed to the flooding. The Missouri River, normally no more than a half-mile wide, expanded to 5-6 miles wide north of St. Joseph and 8-10 miles wide east of Kansas City. Just north of St. Louis, it reached 20 miles wide near its confluence with the Mississippi. As a result, almost half of the 620 square miles of St. Charles County were underwater. **Table 3.21 and Table 3.22** highlight high-water stages and levee failures that resulted from the summer flood of 1993.

Table 3.21. Record High-Water Stages in Missouri During the Summer 1993 Flood

Community	1993 Level	Previous Record	Flood Stage
Mississippi River			
Hannibal	31.8	28.6	16
St. Louis	49.4	43.3	30
Cape Girardeau	48.0	45.6	32
Missouri River			
St. Joseph	32.7	26.8	17
Kansas City	48.9	46.2	32
Jefferson City	38.6	34.2	23
Hermann	36.3	35.8	21
St. Charles	39.5	37.5	25

Source: U.S. Army Corps of Engineers (1993)

Table 3.22. Distribution of Levee Failures by USACE District/Number of Failed or Overtopped Levees, Summer 1993 Flood

Corps of Engineers District	Federal Levees	Non-federal Levees
St. Louis*	12 of 42	39 of 47
Kansas City**	6 of 48	810 of 810
Total Levees	18 of 90	849 of 857

Source: Natural Disaster Survey Report, "The Great Flood of '93."

Notes: The difference in the failure rates above is because most federal levees are designed to withstand a 100- to 500-year flood, while non-federal levees, predominantly protecting agricultural lands, are frequently designed for a flood with a return period of 50 years or less.

*Includes eastern Missouri and portions of Illinois

**Includes northwestern, west-central, and portions of southwest Missouri and areas in Kansas and Nebraska

The 1993-1995 flood disasters inflicted tremendous loss in terms of damage to personal property, businesses, infrastructure/public property, and agriculture. Total losses for all areas impacted during the 1993 flood disasters were estimated at approximately $3 billion, making it the flood of record in most counties. In addition, agricultural losses were estimated at $1.8 billion, as 3.1 million acres of farmland were either damaged or went unplanted because of the 1993 rains. The U.S. Department of Agriculture estimated that 445,000 acres of Missouri River bottomland were destroyed by washouts and sand scouring. While levees designed to protect up to 50-year floods did their jobs, the amount of rain and up-river flooding took their toll. Of the 1,456 public and private levees in the State, approximately 840 were damaged.

Almost every Missourian was at some time affected by the 1993 floods through inundation of roadways, airports, and drinking water and sewage treatment facilities, and by loss of income. The Missouri Department of Labor and Industrial Relations reported that $6.2 million was dispersed for disaster unemployment assistance for people who lost work due to flooding from July 1993 through March 1994. The floods of 1993 and 1994 pointed out that too many Missourians were living in a floodplain. To rebuild in the floodplains, those whose homes sustained substantial damage (50 percent or more) were required to elevate the structures above the base-flood level to protect from future flood damage. Under Missouri's Community Buyout Program, more than $30 million in federal money was committed to moving Missourians voluntarily out of the floodplains through the

acquisition of primary residential properties. As a result of those actions, it is estimated that state taxpayers will save more than $200 million in future flood disaster claims.

Floods of 1998

Severe flash flooding in the summer and fall of 1998 took a heavy toll in terms of lives lost and extensive property damage in several areas of the State. In all, at least 17 people died as a result of the two flood events. Almost all of the casualties occurred when people attempted to drive their vehicles through rushing water, overturned their vehicle into floodwaters, or were trapped and swept off a flooded bridge. Both flood incidents ultimately resulted in presidential disaster declarations to provide state and federal assistance in the declared counties.

Spring 1999 and 2000 Floods

On April 3, 1999, a heavy rainstorm in southeast Missouri caused severe flash flooding in Madison County, including the communities of Fredericktown and Marquand. One death (due to electrocution) was attributed to that flood event when 7 to 10 inches of rain fell over a two-hour period, causing the St. Francois River to crest at twice the height of flood stage. More than 400 homes were adversely affected, with nearly half receiving significant water damage within the living spaces. Seven businesses were damaged, and five were determined to be destroyed. On April 20, 1999, a presidential disaster declaration for individual assistance (DR-1270) was approved for Madison County and five additional counties (Andrew, Cole, Osage, Iron, and Macon) were later approved by FEMA as add-ons to that declaration as a result of subsequent tornadoes and storms. More than 30 Missouri counties were also designated as eligible for disaster relief for agricultural losses suffered from the April storms.

For two consecutive spring seasons, Missouri experienced devastating flash flooding that forced hundreds of people from their homes and caused millions of dollars in property damage to both homes and businesses. Although the flash flooding in both events was confined to a few areas, the type of devastation was equal or greater than some of Missouri's worst river flooding events. On May 6 and 7, 2000, a slow-moving storm unleashed 15 inches of rain in Franklin and Jefferson counties in less than 24 hours. The city of Union in Franklin County was among the hardest hit due to extreme flooding from Flat Creek. In all, 10 counties were included in a presidential disaster declaration (DR-1328) issued on May 12, 2000. Three counties were declared eligible for Public Assistance and Individual Assistance, and seven others were declared for Individual Assistance.

Spring 2003 Flood

Flash flooding occurred on May 7 and 8, 2003, and became a major flooding event across all of southern and central Missouri through the early afternoon of May 9. In addition to the numerous road closures; bridges blocked by debris; evacuations of towns, campgrounds, and parks; and moderate river flooding, many communities had their worst flooding in more than 10 years. In Howell County, the most significant damage occurred after the Warm Fork River washed out a portion of train track four miles southeast of West Plains, resulting in a train derailment. Four locomotives, each weighing 260,000 pounds, and 10 railroad cars were knocked off the tracks pouring out diesel fuel. In addition to all of the flash flooding reports, river flooding became significant as all of the southern Missouri rivers rose above flood stage by the middle of May. Some of the rivers crested at levels equivalent to the 1993 flood event.

Flood of 2004

The month of May 2004 saw severe storms containing heavy rains and large hail. A strong storm moved through the State from west to east, roughly along the Interstate 70 corridor, during the night of May 18–19, 2004. The most severe hit area appeared to be in Cass County south of Kansas City. Twenty-two homes were evacuated in Freeman and Lake Annett in Cass County as a result of major flash flooding.

Spring 2006 Flood

A series of severe weather systems pushed across Missouri in March and April. These storms produced a variety of damaging elements which included high winds, tornados, flooding and heavy snow. Forty-nine Missouri counties received Federal Major Disaster Declarations. Through June 14, 2006, homeowners, renters and business owners who were affected by the severe storms, tornadoes and flooding of March 8-13 and March 30 - April 3, 2006, had been approved to receive more than $32,605,969 million in assistance from FEMA, the U.S. Small Business Administration (SBA) and the SEMA.

Floods of 2007

On January 12-14, a series of severe winter storms swept across Missouri causing heavy damage throughout the State from rain, freezing rain and flooding. An area from Joplin to St. Louis along the I-44 corridor was the heaviest hit. More winter weather came through much of the State on January 20, bringing 4-6" inches of snow in some areas and additional minor ice accumulations. Hundreds of thousands were without power to their homes resulting in 119 shelters being opened across the State.

During the weekend of May 4-7, 2007, a strong upper level storm system generated numerous rounds of heavy rainfall across the Midwest. Even though in the record books the May 2007 floods will not go down as the worst flooding ever experienced in the Midwest, in many locations May 2007 flooding was in the top three events of all time. More significantly, two cities experienced the all-time record flood levels at their locations. The Tarkio River near the city of Fairfax, MO experienced a record high river crest of 25.78 ft. recorded Monday, May 7th. This river stage broke the previous record of 25.60 ft. set on July 23, 1993. The second location to experience record flooding was near the city of Napoleon, MO. At Napoleon, the Missouri River reached a record level of 28.86 ft., eclipsing the previous record of 27.40 ft. set back on May 19, 1995. The Association of Missouri Electric Cooperatives reported that a cooperative in Holt County had an estimated $159,000 in damages as a result of this event.

Heavy rainfall and flash flooding occurred over the Missouri Ozarks and southeast Kansas from the 19th to the 20th of August 2007. The heavy rain was a result of the remnant energy from tropical system "Erin" as it interacted with high levels of moisture in the atmosphere. The heaviest rainfall occurred in a band that affected northern Lawrence, Eastern Dade, northern Greene and southern Polk counties, where 10 to 12 inches of rainfall occurred. Tropical moisture, high radar reflectivity and slow movement to the storms led to the powerful flash flooding which damaged roadways and bridges and caused one death in Laclede County.

Floods of 2008

An unusually early severe weather outbreak hit the Missouri Ozarks Monday afternoon, January 7th, into the early morning hours Tuesday, January 8th, 2008. Numerous supercell thunderstorms spawned at least 33 tornadoes that resulted in significant damage to homes, trees and power lines. The supercell thunderstorms were followed by a violent squall line that produced damaging straight

line winds in excess of 70 mph. In addition, the storms produced torrential rainfall and flash flooding. The storms developed as an intense storm system tracked out of the Rockies and interacted with an unseasonably warm, moist and unstable air mass across the Ozarks.

March 2008

This event was primarily a winter storm disaster with large amounts of snow. However, due to the large amounts of rain and ice buildup that accompanied the storm, flooding was included in the declaration request.

An intensifying wave of low pressure developed on March 17, 2008 in the Texas panhandle, and headed to the lower Midwest. This system tapped into abundant Gulf moisture and combined with a strong upper level jet and a warm, unstable atmosphere to produce extremely heavy rain from southwestern Missouri eastward into southern Indiana over the next three days. The first area it affected was southwestern Missouri, which received most of the heavy rain on March 17th and early on March 18th. Much of the region received four to six inches of rain, with isolated areas had10 inches or more. By the morning of March 18th, the surface low pressure system was located near St. Louis, and heavy rain was falling from the central Ozarks into southern Illinois and Indiana. The NWS cooperative observer located in Cape Girardeau, MO reported 13.84 inches for the 48-hour period from the morning of March 18 to the morning of March 20th. The Cape Girardeau Regional Airport reported 11.49 inches for just the 18th alone. Preliminary measurements indicate that 17.83 inches of rain fell at Cape Girardeau in March 2008. This breaks the previous all-time monthly record at Cape Girardeau of 16.89 inches, set in May of 1973, and as well as the March record rainfall of 11.89 inches sent in 1977. Five Missourians died as a result of these storms–two in Greene County, one in Reynolds County, one in Bollinger County and one in Lawrence County. At one point during the event, the Missouri Department of Transportation reported 190 locations on state roads that were closed due to flooding. A few of those locations would remain closed through August as the year of 2008 continued to set record levels of rainfall in Missouri and the Midwest. Nine cooperatives in the Association of Missouri Electric Cooperatives reported total estimated damages in the amount of $885,800 as a result of this event. In all, 17 counties were included in Presidential Disaster Declaration FEMA-1749-DR, for individual assistance issued on March 19, 2008. Another 78 counties were declared eligible for public assistance.

The period February through April 2008 was the wettest on record for the Midwest region, with an average 11.64 inches of precipitation. This was also the wettest February-April for Missouri with 18.92 inches. The wet weather pattern over the southern Midwest in February and March continued into the first half of April. On April 3rd and April 4th two to four inches of rain fell from the Missouri Ozarks into western Kentucky, southern Illinois, and southern Indiana, with isolated amounts in excess of 6.50 inches. The heavy rain caused another round of flash flooding and road closures in these areas, and exacerbated flooding already in progress on rivers and streams. On April 8-10 another strong spring storm moved through the Midwest on a more northerly track. This storm dropped another 3 to 4 inches of rain on southwestern Missouri, and one to three inches of rain in a band from northwestern Missouri into southeastern Iowa.

June of 2008 was a very wet month across a significant portion of the Midwest. Precipitation was more than 200 percent of normal across much of Missouri. The wet first half of the year, along with the record June rainfall caused devastating flooding and numerous flash floods in Missouri. This resulted in record flooding on parts of the Mississippi River. This flooding exceeded levels reached during the Great Flood of 1993 in some locations. Springfield, MO received 3.88 inches in a day,

breaking the old record for the date of 2.00 daily inches set in 2004. The flash flooding of Galloway Creek in Springfield significantly damaged Galloway Village, a historic section of specialty and antique shops. Water levels reached three feet in just an hour. Flood waters also washed away tons of rock from the railroad line to the James River Power Plant, interrupting coal shipments until workers could finish replacing the rock several days later. Along the Mississippi, many levees were dealing with structural failure possibilities even without overtopping. More rain caused already weakened levees to give way. Several cities were wholly or partially flooded by levee failures or overtopping, including Clarksville, Winfield, Foley, and St. Charles. The Winfield failure was especially illustrative of the fragility of some levees, as the flood waters broke through a 3-inch tunnel dug by a muskrat and water poured out under pressure like a fire hose. Many volunteers and National Guard troops were able to keep most of the levees intact. Three cooperatives in the Association of Missouri Electric Cooperatives reported total estimated damages of $142,000 as a result of this event. Presidential Disaster Declaration FEMA-1773 issued on June 25, 2008, included 27 counties for individual assistance and 72 counties eligible for public assistance.

Spring 2009

A wide swath of severe weather tore across Missouri on May 8, 2009. The fast-moving complex of severe thunderstorms brought damaging winds, large hail and tornadoes to southern Missouri and Illinois. Thousands of trees were uprooted, numerous buildings and homes sustained damage from wind and hail. In addition, three to locally five inches of rainfall caused extensive flash flooding from Crawford County, Missouri to Randolph County, Illinois. Rainfall totals across the southern half of the State reached 200 percent of normal for the first week of the month. Two weather systems tracked across northern Missouri May 12th through the 16th. The heavy rainfall pushed some locations in the State to rainfall totals exceeding 300 percent of normal. Flash flood warnings blanketed the affected areas as storms dumped their rain on saturated ground. Roads were closed due to flooding in many rural and urban areas.

July 2009

An early July low pressure developed along the front in the southern Plains and moved along the front, setting off thunderstorms from Missouri through Ohio. Late on July 2, 2009 two to six inches of rain fell in western Missouri northwest of Kansas City. The rain caused flash flooding in Parkville, MO. The lower levels of 20 homes were flooded in one subdivision when debris blocked drainage tubes at a bridge. In central Missouri, three to four inches of rain fell in Moniteau, Cole, and Osage counties. The week of July 24th brought extremely heavy rains to previously saturated portions of Missouri. Rainfall exceeded 12 inches in portions of northern Missouri, and amounts from 3 to 6 inches were reported from southern Iowa to just north of St. Louis, resulting in flash flood watches and warnings for much of the region. The largest 24-hour rainfall amount reported was 14.95 inches one mile west of Brunswick, MO. A dam on a 2-acre pond at a country club near Kirksville was breached and water was flooding a major highway. Two men were rescued from a tree after their vehicle was swept off of a road by floodwaters in Ralls County, and authorities reported numerous vehicle rescues. The next round of heavy rain came on July 29-30 as the remnants of Hurricane Dolly entered the Midwest. Heavy rain fell from north of Kansas City, MO across north-central Missouri, preventing any recovery from the flooding caused by the previous two systems. In Platte City, MO, 7.70 inches of rain was recorded into the 24-hour period ending at 7:00 a.m. on July 30, and there were numerous reports of 2 to 3 inches of rain in northwestern Missouri. The heavy rain closed many roads and kept rivers and streams in flood. Three cooperatives in the Association of Missouri Electric Cooperatives reported a total estimated $190,000 in damages as a result of this event. In the wake of the week of

heavy rain in Missouri, Mark Twain Lake, a flood control reservoir and major recreational destination, reached a record level of 640.36 feet on July 30, swelling it to twice its normal size. The previous record was 636.77 feet in 1993. On July 30 USACE closed the lake to all boating traffic, and increased the water released through the dam into the Salt River to 50,000 cubic feet per second (cfs). Releases above 12,000 cfs were unprecedented. Authorities also closed the Salt River to recreational boating traffic from the Clarence Cannon Dam to the Mississippi River because of flooding. This had a serious impact on area businesses during the height of the tourist season.

Two tropical systems, Gustav and Ike, brought heavy rain to the central Midwest during the first half of September. Many locations from Missouri through Illinois into southern Michigan received two to three times normal September rainfall, and much of that rain fell the first two weeks of the month. A number of locations set monthly records for precipitation. The heaviest rains occurred across the northern half of the State. In northeast Missouri, Kirksville received a total of 8.14 inches of rain, while in Columbia

7.19 inches of rain from the remnants of Hurricane Ike were reported. The St. Louis area was also hard hit, with O'Fallon reporting 5.84 inches of rain. Three deaths were reported in association with the storm. A woman was killed when a tree was struck by lightning and a limb fell on her in Ladue. Two other people were killed in University City when they were swept away by flood waters while trying to move their vehicles to higher ground. Numerous roads were closed by flooding, including a stretch of Interstate 70. At the peak of the storm nearly 106,000 people were without power in the St. Louis Area.

Spring 2010

On July 27, 2010, a major disaster declaration was requested due to severe storms, flooding, and tornadoes during the period of June 12 to July 31, 2010. The Governor requested a declaration for Individual Assistance for 11 counties and Public Assistance for 29 counties and Hazard Mitigation for the entire State of Missouri. During the period of July 7 – 20, 2010, joint Federal, State, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

On August 17, 2010, the President declared that a major disaster exists in the State of Missouri. This declaration made Public Assistance requested by the Governor available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis for emergency work and the repair or replacement of facilities damaged by the severe storms, flooding, and tornadoes in Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Chariton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Lafayette, Lewis, Livingston, Mercer, Nodaway, Putnam, Ray, Schuyler, Scotland, Sullivan, and Worth Counties. This declaration also made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

Spring 2011

On May 5, 2011, a major disaster declaration was requested due to severe storms, tornadoes, and flooding beginning on April 19, 2011, and continuing. The Governor requested a declaration for Individual Assistance for 29 counties, Public Assistance for 38 counties, and Hazard Mitigation

statewide. The Governor further requested direct Federal assistance. During the period of April 27 to May 5, 2011, joint Federal, State, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

On May 9, 2011, the President declared that a major disaster exists in the State of Missouri. This declaration made Individual Assistance requested by the Governor available to affected individuals and households in Butler, Mississippi, New Madrid, St. Louis, and Taney Counties. This declaration also made Public Assistance, including direct Federal assistance requested by the Governor available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis in St. Louis County. Finally, this declaration made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

Summer 2011

On July 25, 2011, a major disaster declaration was requested due to flooding during the period of June 1 to August 1, 2011. The Governor requested a declaration for Individual Assistance for eleven counties, Public Assistance for 22 counties and Hazard Mitigation for the entire State of Missouri. During the period of July 18-22, 2011, joint federal, state, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the state and the affected local governments, and that Federal assistance is necessary.

On August 12, 2011, the President declared that a major disaster exists in the State of Missouri. This declaration made Individual Assistance requested by the Governor available to affected individuals and households in Andrew, Atchison, Buchanan, Holt, Lafayette, and Platte Counties. This declaration also made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

The table below was pulled from a Corps of Engineers Vulnerabilities assessment concerning the 2011 flooding. It summarizes the studies research within each sector.

Table 3.23. 2011 Flood Vulnerability Report

2011 Flood Vulnerability Report			
Vulnerability Report Section	***Salient Feature Addressed***	***Key Points***	***Vulnerability/ Remaining Work***
Economics	Economic Impact to Basin	• Impacted 1+M acres, 10,000+ people, and almost 6,000 structures • Corps Reservoirs and emergency operations prevented nearly $8B in damages	• There is need to update Stage Damage Curves as well as Socioeconomic Data

2011 Flood Vulnerability Report

Vulnerability Report Section	*Salient Feature Addressed*	*Key Points*	*Vulnerability/ Remaining Work*
Reservoirs and Water Management	Reservoir and Dam Infrastructure	• All critical assessments have been completed • Additional funding may be needed to restore system, pending studies	• Ft Peck Plunge pool and Ring Gates continue to be assessed and evaluated • Need to evaluate unlined spillways at Oahe and Pipestem • Some other Miscellaneous measures to restore existing systems • Depending on assessments, some operating restrictions may be implemented
	Water Management	• There are currently no formal operating restrictions on system • Record runoff that flowed into system needed to exit system	• Need to update Water Control Manuals • Implementing the 6 Independent External Panel Recommendations • Restore/maintain all project features to maximize flexibility in system
River Corridor and Conveyance	Floodway and Channel Performance	• Bank stabilization navigation projects, Navigation Channel, Habitat areas, and sedimentation and aggradation issues are being addressed and/or evaluated • Considerable damage did occur in river structures. Most known repairs funded	• assessments and repairs are being addressed • Several river bends may require attention due to damage or flood determination • Additional studies may be required to fully assess channel condition • Complete the flow corridor study as planned
	Levees	• Critical repairs have been made • Some overtopping and under seepage was issue throughout basin	• Some flow constrictions exist in levee alignment • Repairs are funded but will carry into Fiscal Year 13
Other Considerations	Tribal and Cultural Resources	• Cultural sites were impacted and are being assessed	• Tribes and others need to remain engaged thru Programmatic Agreement meetings and other partnering meetings
	Communications	• MRJIC worked to communicate and engage local state, and Federal and Tribal interests • MRFTF was a successful joint Federal effort to restore system	• MR Basin Interagency Roundtable(MRBIR) will inherit tasks/initiatives started by MR Flood Task Force (MRFTF)
Shared Responsibilities	Flood Risk Management	• Federal Government has little control over local land uses • Federal Government has little control over local land uses • Local and some states can help in reducing flood risk and expose	• Federal Government can assist when and if requested • MRBIR will continue the Stakeholder Communications started with MRFTF • To understand FRM, the 8 Authorized Purposes need continued education throughout the basin

Summer 2013

A large complex of thunderstorms produced heavy rainfall in July 2013 which led to widespread flooding and isolated reports of wind damage. This was the start of an unsettled and very wet weather pattern that lasted into early August.

Fall 2014

On September 9 and 10, unusually intense and heavy rainfall occurred over parts of northern Missouri, especially along and north of Highway 36. Cooperative weather observers in Holt, Grundy, Linn, Macon, Adair, Knox and Lewis counties reported more than 7 inches of rain, much of it falling in less than 6 hours. Extensive flooding and flash flooding was reported with numerous reports of closed and washed out roads.

Widespread bottomland flooding was also reported. Highest amounts were reported in northern Holt county (9.48") and northeastern Linn county (10.42"). http://climate.missouri.edu/news/arc/oct2014.php

Summer 2015

Major flooding occurred on portions of the Mississippi River. The active June weather pattern continued through July, bringing fronts that moved in and near the region's river basins. The wet period of spring and summer resulted in prolonged high water levels in lakes, rivers and streams. These conditions unfortunately contributed to an increased number of drowning deaths. The Missouri State Highway Patrol reported 34 drownings this year, while 25 were reported in all of 2014. Most of the fatalities have been attributed to flooding.

Winter 2015-2016

Historic flooding impacted Missouri during December 2015 with the eastern and southern sections of the State experiencing the brunt of the extreme weather. A highly unusual heavy rainfall event from December 26 through 29 dropped 7.5-10 inches of rain along a 60-mile wide corridor extending from just south of Joplin to St. Louis. Rivers and streams reacted quickly to the post-Christmas rainfall event, and flash flooding was widespread with hundreds of water rescues reported, especially over the southern half of the state. There were 27 flood fatalities reported in 2015. This was more than the combined number for the previous 7 years and represented the highest number since 1993, the highest number on record for the State. Of those 27 deaths, 23 (85%) were killed in motor vehicles. Of the 49 deaths recorded during the floods of 1993, 35 (71 percent) were from flash floods. In that same category, 20 deaths (77 percent) were related to motor vehicles caught in flash floods or attempting to cross high water. Missouri's river flooding in 1993 claimed 14 lives, with 6 deaths (23 percent) attributed to motor vehicles. Drowning, electrocution and cardiac arrest are the remaining causes of flood related deaths.

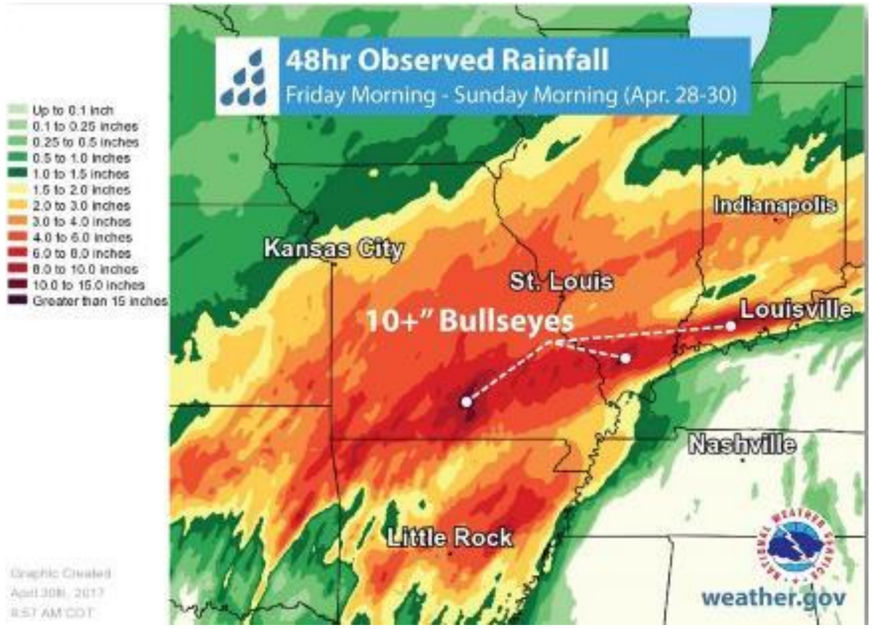
Transportation was also severely impacted by the flooding, with portions of major interstates closed for a period of time, including I-44, I-55, and I-70. Amtrak service was temporarily suspended and barge traffic along the Mississippi River at St. Louis was shutdown. Record flood crests were reported along parts of the Mississippi (Cape Girardeau, Thebes), Meramec (Pacific, Eureka, Valley Park, Arnold) and Gasconade Rivers (Jerome), among other streams and tributaries. Thousands of homes and hundreds of businesses were flooded as President Obama designated Missouri a federal disaster area on Saturday, January 2.

Spring 2017

A powerful storm system brought torrential rainfall and historic flooding to the Missouri Ozarks and southeastern Kansas from Friday night, April 28 through Sunday, April 30. Storm total rainfall amounts generally ranged from 4 to 8 inches with some areas of far southern and south-central Missouri receiving from 10 to 12 inches. This rainfall event resulted in widespread and historic flooding. Numerous roads, bridges and buildings were destroyed. Many roads were flooded through the event including state highways and Interstate 44. Several rivers reached major and historic levels, including the Mississippi River which reached major flood stage in many locations north of the confluence of the Ohio River and the St. Francis River which crested at a new record high at the Patterson gage.

The heavy rainfall events in April were followed by another heavy rainfall event in early May. Total rainfall amounts for the May 11th event ranged from around one-half to one inch over mainly southern Missouri to one and one-half to over two inches over far western Missouri and extreme southeast Kansas. The heaviest rainfall amounts occurred over an area roughly between US Highways 60 and 54. The rain fell over saturated soils saturated from the April event prompting two flash flood warnings and several areal flood warnings.

Figure 3.21. Observed Rainfall April 28-30, 2017



Source: NWS; https://www.weather.gov/sgf/28-30AprilHistoricFloodingEvent

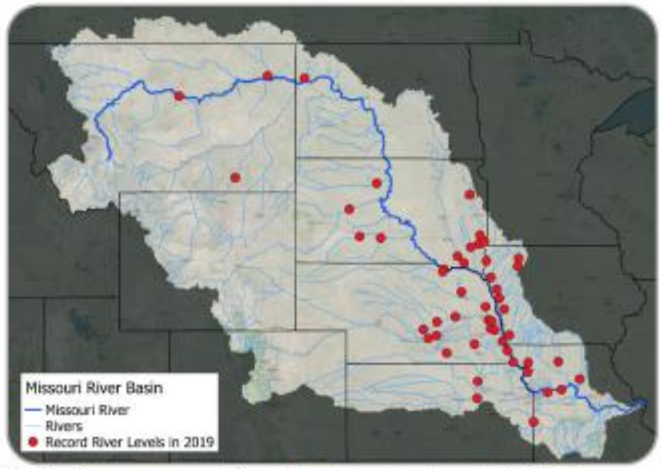
Spring-Summer-Fall 2019

A number of events led to the severe flooding and record rainfall that occurred across the Missouri Basin in 2019. Portions of the Missouri River Basin were above flood stage for the majority of the year, starting with the mid-March "bomb cyclone" event and continuing with heavy rainfall events during the late spring, summer, and autumn. According to the U.S. Geological Survey's WaterWatch, there were approximately 75 record peaks in the Basin, with 27 of these stream gages having at least 30 years of record. **Figure 3.22** presents the locations of record flood stage locations, including the following locations in Missouri with over ***200 consecutive days above flood stage***:

- St. Joseph, MO: 268 days, ending December 6th
- Napoleon, MO: 271 days, ending December 9th
- Waverly, MO: 272 days, ending December 10th

The flood event impacted agriculture, infrastructure, and ecosystems. Flooding impacts were noted for row crops, livestock, and cropland/pastureland. Extreme wetness and flooding caused issues for landowners. Thousands of acres of land were impacted by sediment deposition, erosion, and scouring. In some cases, the cost of remediation far exceeded the value of the land, leaving some landowners with difficult decisions. Damage to infrastructure included roads, bridges, and rail lines; dams and levees; and other structures. Damage to roads and bridges caused many transportation issues across the region. For instance, I-29 in Missouri and Iowa was closed on multiple occasions, causing traffic to be rerouted, and flooded roads in rural areas made it difficult for farmers to reach their fields. Homes, businesses, and government buildings were also impacted by the flooding.

Figure 3.22. Record River Levels in Missouri River Basin, 2019



Preliminary record river levels. Courtesy MBRFC.

2022

During the early morning of Tuesday, July 26th, 2022, thunderstorms set up along the I-70 corridor in Missouri and I-64 corridor in Illinois. Several rounds of thunderstorms with rainfall rates exceeding 2 inches-per-hour affected this area, including the St. Louis metropolitan area. Nearly 11 inches of rain fell over the course of 8 hours in an axis from Hawk Point, MO to St. Peters, MO. A longer axis of over 8 inches of rain fell from northern Montgomery County in Missouri to St. Clair County in Illinois, causing multiple swift water rescues and scores of flooded interstates and homes across the St. Louis metropolitan area. St. Louis-Lambert International Airport also observed a new all-time record for daily precipitation: 8.64 inches of rain fell since midnight CST. This value broke the previous record of 6.85 inches, which occurred on August 20th, 1915, due to the remnants of the Galveston 1915 Hurricane. The storm-total rainfall was 9.07 inches but spans two days. Two fatalities were reported: one in St. Louis City, where a man drowned in his car near Skinker Blvd, and another in Hazelwood where a man drowned attempting to flee his flooded truck.

Probability of Future Hazard Events

Flooding has resulted in more federal disaster declarations in Missouri than any other hazard in the past three decades. With 44 disaster declarations over the 47-year period from 1975 to 2022, there is a 94% likelihood of a flooding event in Missouri in any given year. Prior to the Statewide flood of record, the Great Flood of 1993, Missouri received major disaster declarations due to flooding in the spring of 1990, October 1986, June 1984, December 1982, August 1982 (Jackson County), April 1979, September 1977, May 1977, July 1976, June 1974, and for extensive flooding in April 1973 and again in November 1973. Since the Great Flood of 1993, there have been 25 major flooding events which include the events of April 1994, June 1995, October 1998, April 1999, May 2000, May 2002, May 2003, June 2004, March 2006, January 2007, March 2008, June 2009, August 2010, May 2011, June 2011, July 2013, October 2014, August 2015, August 2016, December 2016, May 2017, July 2019, July 2020, September 2021, and July 2022. Further details on these flood-related major disaster and emergency declarations are presented in **Table 3.16** in **Section 3.2.3**.

Additionally, flash flooding can occur virtually anywhere in the State experiencing an abundance of rainfall in a very short time span, as with the November 1993 flood disaster, floods of 1998 and 1999, and recent July 2022 event. The backing up of tributary stream flows creates flooding problems along the Mississippi River, especially in the southern area of the State where the land tends to be very flat and at low elevations.

Even though many flood control projects have been implemented and directly aid in flood prevention, the State is still flood-prone due to its geography and location.

The threat of flooding is more likely in the spring, when late winter or spring rains, coupled with melting snow, fill river basins with too much water too quickly. Spring also represents the onset of severe weather in the form of thunderstorms, tornadoes, and heavy rains, which can generate flash flooding along these storm fronts. As historically demonstrated, severe flooding can occur in Missouri at any time of the year however May is the most comment month.

Missouri has experienced significant drought in recent years, which can, ironically, lead to increased flooding. Dry, parched soils can also increase storm water run-off, as well as, increased evapotranspiration, flash droughts, water deficits, reduced vegetative growth, and wildfires. Additionally, extreme weather events, such as drought and severe thunderstorms, may increase the potential for flooding.

Changing Future Conditions Considerations

If departure from normal with respect to increased precipitation intensity continues, frequency of floods in Missouri is likely to increase as well. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. For Missouri specifically, annual precipitation has been generally above average since 1990, while summer precipitation has been variable, with no extended periods of above or below average levels. Rainfall during the four wettest days of the year has increased about 35 percent, and the amount of water flowing in most streams during the worst flood of the year has increased by more than 20 percent.

It is likely (66-100% probability) that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century across the globe. More specifically, it is "very likely" (90-100% probability) that most areas of the United States will exhibit an increase of at least 5% in the maximum 5-day precipitation by late 21st century. As the number of heavy rain events increase, more flooding and pooling water can be expected.

Flooding occasionally threatens navigation and riverfront communities, and greater river flows could increase these threats. In April and May 2011, a combination of heavy rainfall and melting snow caused a flood that closed the Mississippi River to navigation, threatened Caruthersville, and prompted evacuation of Cairo, Illinois, due to concerns that its flood protection levees might fail.

The expected increases in rainfall frequency and intensity are likely to put additional stress on natural hydrological systems and community stormwater systems. Heavier snowfalls in the winter will lead to intensified spring flooding, and groundwater levels will remain high even in non-floodplain areas. Such changes in climate patterns can lead to the development of compounding events that interact to create extreme conditions. Flooding caused by high groundwater levels typically recedes more slowly than riverine flooding, slowing the response and recovery process. Groundwater-fed rivers and streams are also likely to experience heightened flooding when groundwater levels are high.

Jurisdictions updating or installing stormwater management systems should consider potentially larger future discharge amounts when sizing culverts and drainage ways; storage capacity can also be increased by building retention basins to hold excess stormwater. Communities already prone to flooding should be prepared for a potential increase in facility closures and/or damages, as well as an increase in public demand for flood response and assistance. Natural features that experience repeated flooding may manifest changes in the form of stream bank instability and changing shoreline, floodplain, and wetland boundaries.

Communities may also wish to plan for the potential loss of cropland and damage to both private property and public infrastructure such as bridges.

The environmental impacts of flooding include erosion, surface and groundwater contamination, and reduced water quality. The threat of more frequent flood events may thus be a concern particularly for communities who depend on lakes, rivers, or trout streams for tourism. Rural communities may experience increases in well contamination and road washouts, while urban areas may be particularly vulnerable to flash flooding as heavy rain events quickly overwhelm the ability of a more impermeable environment to absorb excess stormwater.

State Vulnerability Overview

The vulnerability of Missouri to flooding is significant. For the 2023 State Plan Update, SEMA used the most recent release of Hazus, version 6.0, to model flood vulnerability and estimate flood losses for all 114 counties and the City of St. Louis due to depth of flooding. Additional hazard data inputs were utilized, as available, to perform Hazus Level 2 analyses. This included the extensive use of the FEMA special flood hazard area data and RiskMAP flood risk datasets and resulted in Missouri being among the first in the nation, if not the first in the nation, to do so.

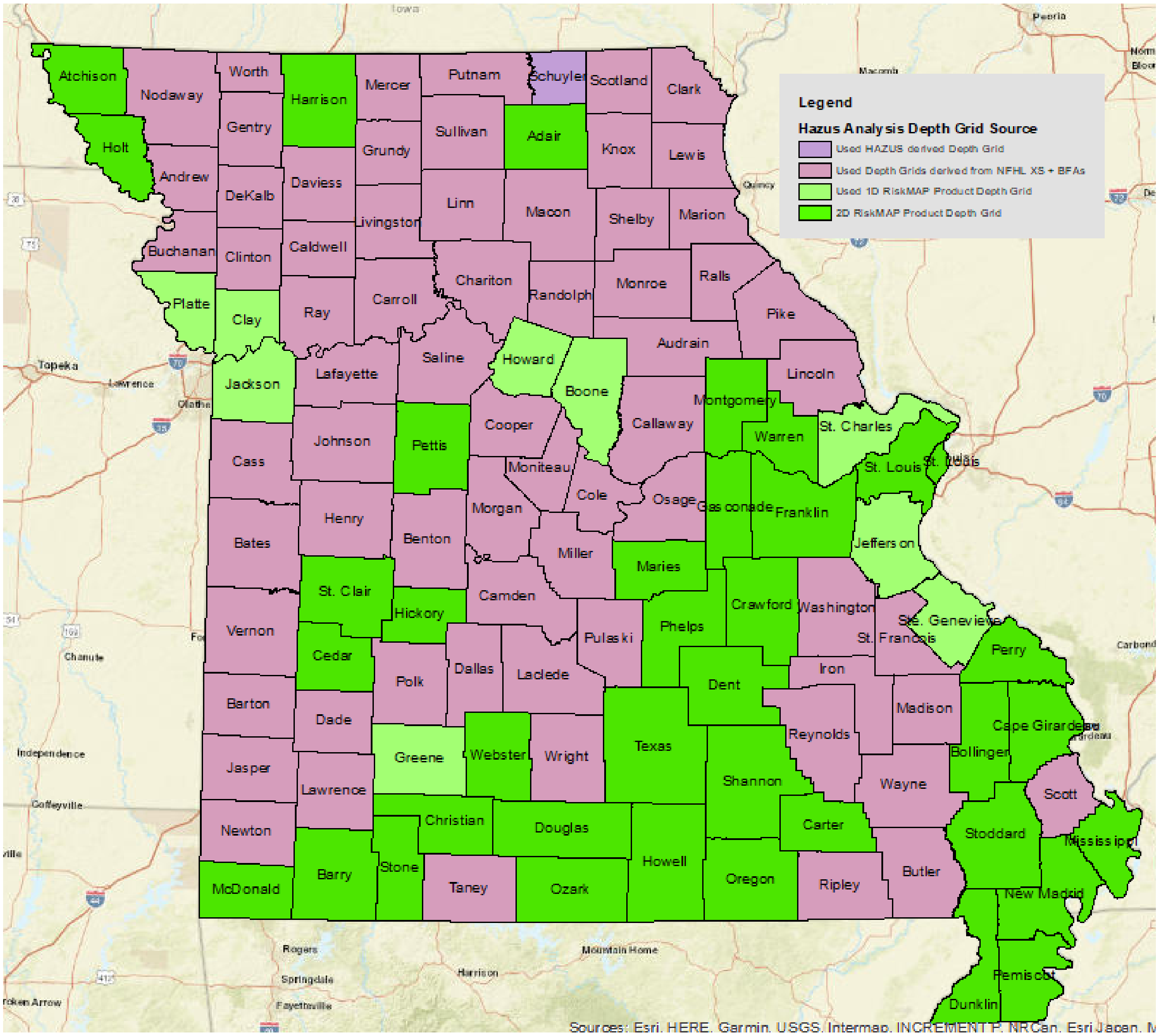
Flood Hazard Area and Depth of Flooding Determinations

For the Hazus analysis, the flood hazard area and depth of flooding was determined for each county using one of the following three methods:

1. **For counties without digital FIRMs**, the Hazus software was utilized to generate the flood hazard boundary and associated depth of flooding. This analysis applies to only 1 county in this update. Model parameters include:
    - Thirty-meter resolution Digital Elevation Models (DEM) were used as the terrain base to develop hydrologic and hydraulic models
    - Streams and rivers with a minimum drainage basin area of 10 square miles were modeled as all experiencing a base flood at the same time
    - U.S. Geological Survey hydrologic regional regression equations and stream gage data were included in Hazus
2. **For counties with digital FIRMs,** the regulatory special flood hazard area was utilized. Next, depth grids were generated using cross sections from the FIRM database and/or hydraulic models in combination with the terrain elevation data from which the DFIRM was derived. This analysis applies to 61 counties and the City of St. Louis.
3. **For counties with RiskMAP flood risk datasets**, the regulatory special flood hazard area was utilized along with the 1-percent annual chance flood depth grid, a non-regulatory product. This analysis applies to 42 counties. Flood depth grids are rasters where depth is calculated as the difference in feet between the water surface elevation and the ground surface elevation. As a further refinement, 36 counties had 2D

Figure 3.23 indicates which analysis was performed per county.

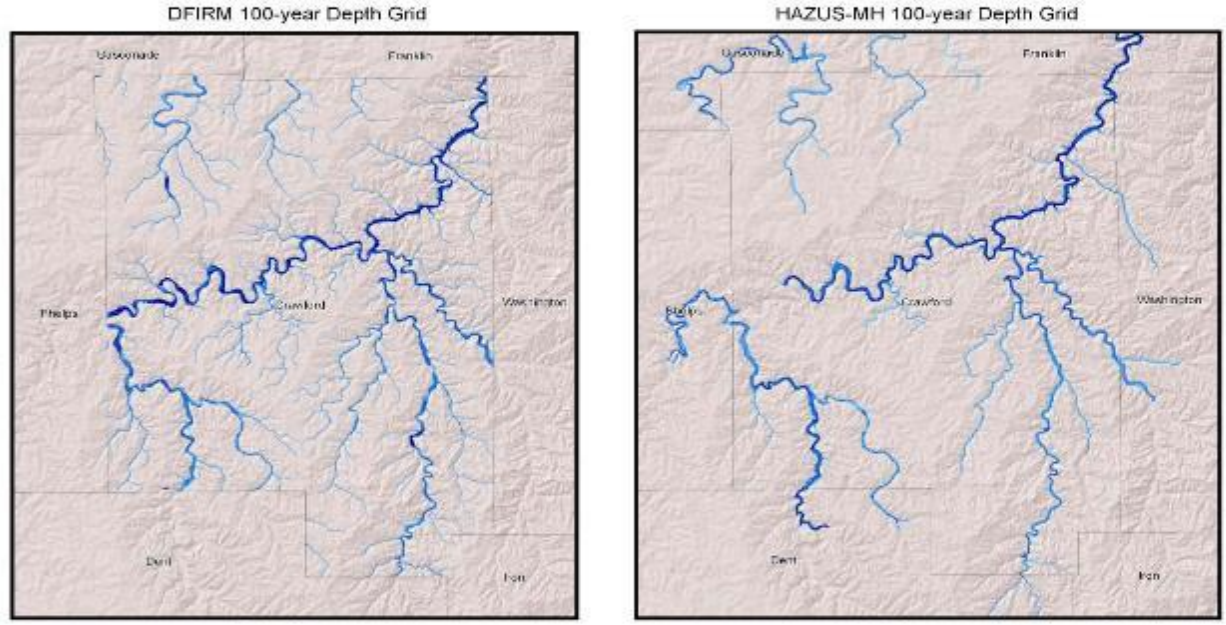
Figure 3.23. RiskMAP, DFIRM and Hazus based Depth Grids used in Hazus Analysis



Defining the flood hazard area and depth of flooding from the digital FIRM data and the RiskMAP flood risk datasets (methods 2 and 3) are preferred over production within Hazus (method 1), because the floodplains derived from digital FIRM and RiskMAP datasets are more comprehensive and accurate than those produced entirely by Hazus, which will result in more accurate vulnerability and loss estimations. The hydrology and hydraulics model used to produce the digital FIRM floodplains and RiskMAP datasets creates streams based on drainage areas less than 1 square mile, while the Hazus model uses a larger 10 square mile drainage area. The smaller drainage area in the model generates more streams per unit area.

As an example, **Figure 3.24** provides a comparison between a digital FIRM floodplain and a Hazus-generated floodplain data for Crawford County.

Figure 3.24. Crawford County: DFIRM and Hazus 100-year Flood



When DFIRM boundaries are used to generate a user-defined depth grid, the more accurate, surveyed floodplain boundaries and flood depths are preserved. It should be noted because of the recognition of this increased accuracy, user-generated depth grids were produced wherever digital FIRM data was available, both with regards to detailed and approximate (Zone A) flood zones. These data were used in conjunction with available LIDAR data from the Missouri Spatial Data Information Service and the US Army Corps of Engineers. In areas that had digital FIRM data where LiDAR was not entirely available, USGS 10-meter digital elevation models were used to supplement these gaps in LiDAR coverage.

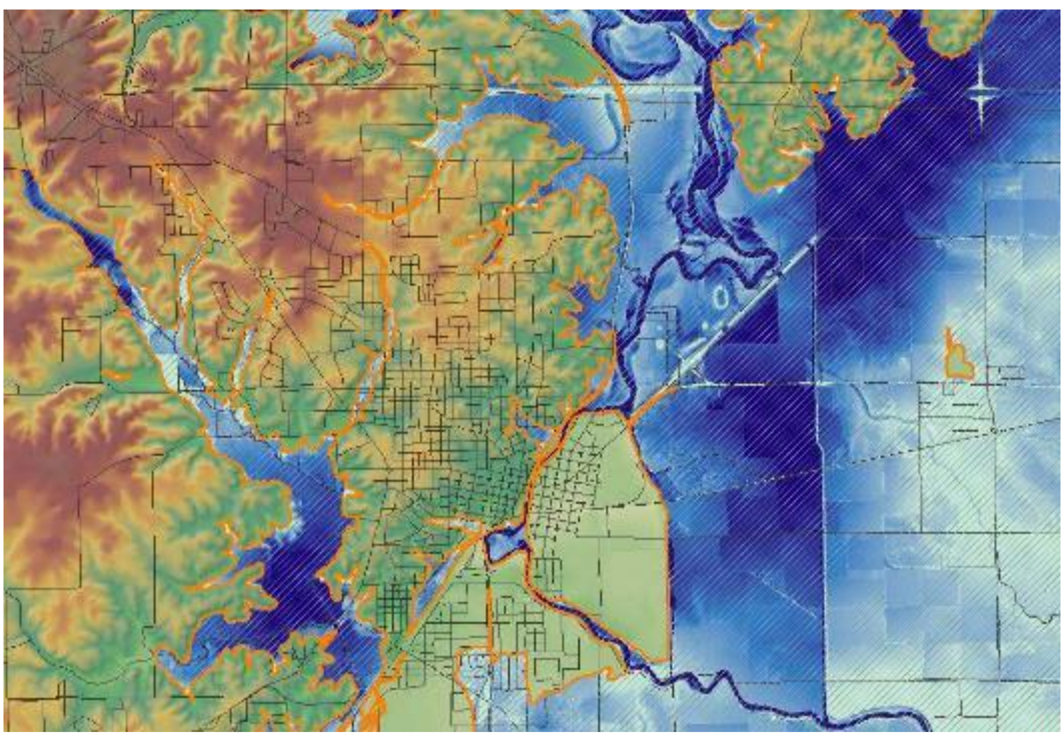
In order to automate the process of generating user-generated (digital FIRM) depth grids in areas where they were not previously produced as part of the DFIRM project, ArcGIS Model-builder was utilized to create a series of models using DFIRM and elevation data as inputs. The methodologies for approximate and detailed flooding were developed separately to allow for the most accurate results possible. **Figure 3.25 and Figure 3.26** each show a sample of a depth grid generated by the model and then input into Hazus for flood vulnerability and loss analysis.

Within **Figure 3.26,** the black lines define census blocks. The smaller the census blocks and the more densely clustered the block polygons, the more likely the area is to be densely developed and populated. The orange line represents the modeled base flood hazard boundary. The blue color indicates flood depth, with deeper blue representing deeper water.

Figure 3.25. Example of a DFIRM Depth Grid in Approximate Areas — Carroll County

Source: Hazus 2.1 and DFIRM

Figure 3.26. Example of a DFIRM Depth Grid in Detailed Areas — Butler County



Source: Hazus 2.1and DFIRM

Building Inventory

For the 2018 State Plan, SEMA enhanced the Hazus analysis statewide with a structure inventory dataset developed by the University of Missouri GIS Department (MSDIS) to indicate the number of structures exposed to the risk. MSDIS created a point and/or footprint dataset for every roof line in every county in the state of Missouri. This dataset is attributed with the type of structure such as Residential, Commercial, etc. To the MSDIS dataset, additional building footprints identified by LiDAR through the Risk MAP process were added. The MSDIS and LiDAR footprint dataset was intersected with the depth grid outside of the Hazus environment for this risk assessment analysis to give an estimated number of structures, by type, exposed to risk of flooding with the flood zone attributed and the estimated depth of water for the twelve counties with existing depth grids from FEMA RiskMAP Products. Tables include both results:

- Hazus building inventory with enhanced Level 2 essential facility data from HSIP summarized to the census block level
- MSDIS building inventory intersection with the floodplain summarized to the county level.

For the 2023, SEMA further enhanced the Hazus analysis for 38 counties by leveraging building footprints derived from LiDAR-point cloud classified data developed as part of the CTP RiskMAP Program. **Figure 3.27** is an example of the footprints.

Figure 3.27. Example of a LiDAR Derived Footprints

Source: SEMA RiskMAP Program

Flood Insurance Claims Analysis

In addition to the Hazus flood runs and local mitigation plans, SEMA analyzed National Flood Insurance Program (NFIP) flood-loss data to determine areas of Missouri with the greatest flood risk. Missouri flood-loss information was obtained from PIVOT, FEMA's Federal Insurance and Mitigation Administration's new web-based processing system. To date Missouri has sustained 49,868 losses (26,371 NFIP claims and 23,497 Write-Your-Own (WYO) claims) resulting in a total of $35,944,225 in payment.

With this flood-loss information, there are noted limitations, including:

- Only losses to participating NFIP communities are represented
- Communities joined the NFIP at various times since 1978
- The number of flood insurance policies in effect may not include all structures at risk to flooding
- Some of the historic loss areas have been mitigated with property buyouts

Despite these limitations, the data depict a pattern of historic flood losses in the State. The greatest losses have been in the counties along the Mississippi River corridor, particularly St. Charles, St. Louis, Jefferson, and Lincoln Counties. Counties along the Missouri River corridor also have considerable claims and losses, particularly Holt County. **Table 3.24** lists the details of the 10 Missouri counties with the greatest historic dollar losses. It can be seen from these top 10 counties that nearly 1/3 of the total coverage has been paid out in claims since the inception of the NFIP. **Figure 3.28 and Figure 3.29** present the geographic distribution of flood payouts and claims by county across the entire state. Please note that only communities that participate in the National Flood Insurance Program can have flood insurance losses. Uninsured losses are not depicted in these tables and figures.

Table 3.24. Top 10 Counties for Flood Insurance Dollars Paid (Historical), 1978-March 2022

County	Dollars Paid (Historical)	Flood Claims	Current Policies	Coverage
ST. LOUIS COUNTY	$211,639,955	11,251	3,270	$940,987,500
ST. CHARLES COUNTY	$149,668,246	9,833	1,570	$378,467,500
JEFFERSON COUNTY	$66,103,960	4,499	924	$204,100,200
LINCOLN COUNTY	$36,274,056	2,212	272	$33,270,000
HOLT COUNTY	$39,243,276	1,252	220	$33,812,400
JACKSON COUNTY	$45,138,261	2,107	945	$316,444,100
FRANKLIN COUNTY	$31,185,083	1,074	285	$57,102,300
BUCHANAN COUNTY	$22,780,355	619	336	$68,431,400
TANEY COUNTY	$18,517,491	399	433	$95,727,100
PIKE COUNTY	$10,096,678	914	89	$9,001,100
Totals	**$630,647,363**	**34,160**	**8,344**	**$2,137,343,600**

Source: FEMA PIVOT, March 2022

Additional flood insurance claim statistics and analyses, addressing repetitive loss (RL) and severe repetitive loss (SRL) properties, are provided in Section 4.3, Repetitive Flood Loss Strategy.

Figure 3.28. Map of Dollars Paid Historically for Flood Insurance Losses in Missouri by County, 1978 - March 2022

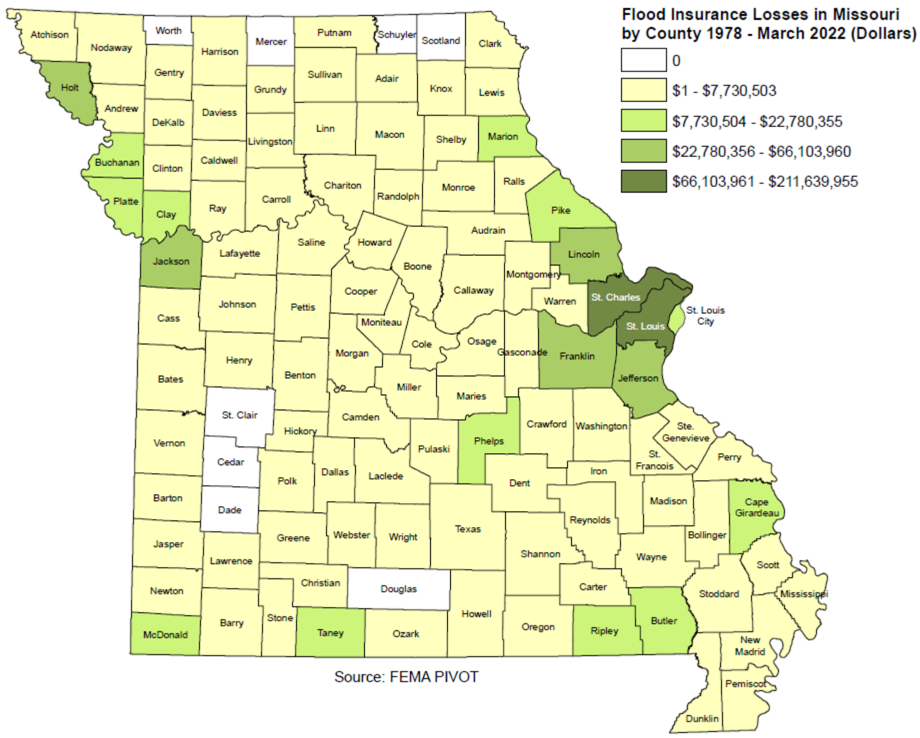
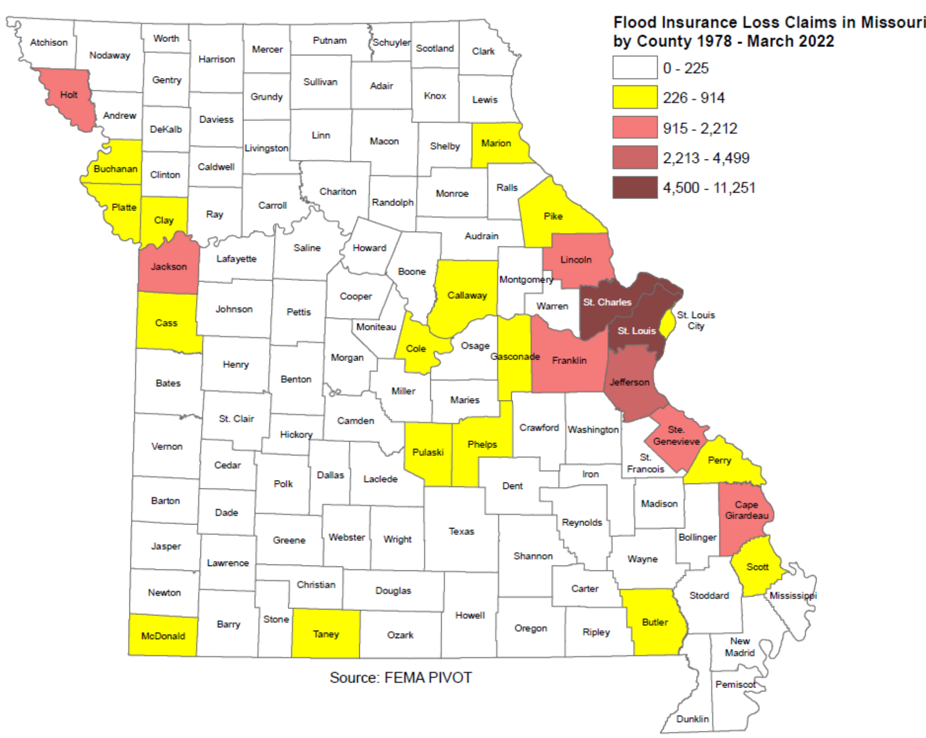


Figure 3.29. Flood Loss Claims in Missouri by County, 1978 - March 2022



State Estimates of Potential Losses

The intent of this analysis was to enable the State to estimate where flood losses could occur and the degree of severity using a consistent methodology. The statewide analysis used best available data; that is, digital effective FIRM data coupled with LiDAR derived building footprints. The computer models help quantify risk along known flood-hazard corridors such as along the Mississippi and Missouri Rivers. In addition, flood losses are estimated for certain lesser streams and rivers where the flood hazard may not have been previously studied.

The Hazus analysis provides the number of buildings impacted, estimates of the building repair costs, and the associated loss of building contents and business inventory. Building damage can also cause additional losses to a community as a whole by restricting a building's ability to function properly. Income loss data accounts for losses such as business interruption and rental income losses as well as the resources associated with damage repair and job and housing losses. These losses are calculated by Hazus using a methodology based on the building damage estimates.

Flood damage is directly related to the depth of flooding. For example, a two-foot-deep flood generally results in about 20 percent damage to the structure (which translates to 20 percent of the structure's replacement value). Hazus takes into account flood depth when modeling damage (based on FEMA's depth-damage functions). Hazus reports capture damage by occupancy class (in terms of square footage impacted) by damage percent classes. Occupancy classes in Hazus include agriculture, commercial, education, government, industrial, religion, and residential. Damage percent classes are grouped by 10 percent increments: 1-10 percent, 11-20 percent, etc., up to 50 percent. Buildings that sustain more than 50 percent damage are considered to be substantially damaged.

The displaced population is based on the inundation area. Individuals and households will be displaced from their homes even when the home has suffered little or no damage either because they were evacuated (i.e., a warning was issued) or there was no physical access to the property because of flooded roadways. Displaced people using shelters will most likely be individuals with lower incomes and those who do not have family or friends within the immediate area. Age plays a secondary role in shelter use in that there are some individuals who will go to a public shelter even if they have the financial means to go elsewhere. These will usually be younger, less established families and elderly families (Hazus User's Manual). Hazus does not model flood casualties given that flood-related deaths and injuries typically do not have the same significant impact on the medical infrastructure as those associated with earthquakes.

Hazus impact analyses were completed all counties, and the City of St. Louis, to see which counties ranked the highest on these risk indicators (see **Table 3.26** and figures that follow). Using GIS, Hazus flood results were mapped to show flood loss potential and how it varies across the State. The primary indicators used to assess flood losses were:

- **Direct building losses** are calculated within Hazus from US Census data.
- **Loss ratio of the direct building losses compared to overall building inventory -** The loss ratio of the direct building losses compared to overall building inventory per county gives an indication of the severity of impacts on community sustainability. While a large urban area may have the greatest dollar losses, it may be able to absorb the impact better than a more rural area where a flood could impact a significant amount of the infrastructure in the entire county.
- **Count of Residential Buildings Exposed to Flooding (MSDIS)** – To determine the number of residential buildings exposed to the 1-percent annual chance flood event, the MSDIS dataset was intersected with the depth grids outside of the Hazus environment. This provides an indication of

the potential magnitude of a flood event. This exposure count was updated for 18 counties using the draft datasets available from the SEMA CTP Mapping Program.

- **Count of Residential Buildings Potentially Damaged by Flooding (Hazus) –** To determine the number of damaged residential structures, the analysis performed within Hazus utilized US Census data to estimate the number of residential structures which are at risk of damage and the number expected to receive substantial damage during a 1-percent annual chance flood event. Note, there are instances where the Hazus analysis predicted a greater number of damaged buildings than were identified with the exposed MSDIS points. This is due a fundamental premise of the Hazus Level 1 flood loss methodology that the buildings are uniformly distributed within census blocks.
- **Income losses, Population displaced by the flood, and Shelter needs** – all computed within Hazus from US Census data

Table 3.25 lists the top ten most severely impacted counties based on building loss, loss ratio, and displaced population indicators. Boone, Butler, Clay, Jackson, Jefferson, McDonald, St. Charles, and St. Louis Counties are present on more than one of these lists and are the most vulnerable to the 100-year flood. Clay and Jackson Counties are split by the Missouri River and are heavily populated with Kansas City metropolitan communities. St. Charles and St. Louis Counties are also split by the Missouri River; they are heavily populated with St. Louis City metropolitan communities. Boone and Jefferson Counties border the Missouri River. McDonald County is located in the southwestern corner of the state and is subject to flooding from the Elk River.

Table 3.26 A and B and the figures that follow present the results of the primary indicators for each of Missouri's 114 Counties and the City of St. Louis.

Table 3.25. Top Ten Counties at Risk to the 100-year Flood for Building Loss, Loss Ratio, and Displaced Population

Building Loss
Jackson
St. Charles
Jefferson
St. Louis
Boone
Clay
McDonald
Butler
Cole
Jackson

Loss Ratio
McDonald
Wayne
Ralls
Holt
Hickory
Stone
Butler
Madison
Osage
Ripley

Displaced Population
St. Louis
Jefferson
St. Charles
Boone
Jackson
Butler
Clay
Stoddard
Jasper
New Madrid

Table 3.26. A. Total Direct Building Loss and Income Loss to all Counties and the City of St. Louis

County	Countywide Building Exposure	Structural Damage	Loss Ratio	Contents Loss	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	# Hazus UDF damaged structures	#Substantially damaged	# Displaced People	# Shelter Needs
Adair	$2,632,932,100	$6,643,700	0.25%	$3,588,100	$360,000	$10,591,800	$10,588,200	$21,180,000	112	40	198	92
Andrew	$2,097,000,488	$35,492,266	1.69%	$21,725,989	$453,486	$57,671,741	$271,119	$57,942,860	78	23	998	238
Atchison	$814,645,800	$13,304,200	1.63%	$14,308,400	$590,000	$28,202,600	$604,197,400	$632,400,000	1,244	26	673	18
Audrain	$3,269,341,909	$9,246,007	0.28%	$11,990,023	$386,618	$21,622,648	$54,710	$21,677,358	26	0	336	130
Barry	$3,625,078,100	$37,198,400	1.03%	$25,805,000	$18,750,000	$81,753,400	$286,466,600	$368,220,000	596	263	1,324	203
Barton	$1,720,280,105	$20,284,074	1.18%	$18,203,874	$635,853	$39,123,801	$103,341	$39,227,143	111	15	1,109	370
Bates	$2,006,219,409	$19,806,272	0.99%	$12,745,022	$712,447	$33,263,742	$49,847	$33,313,588	36	4	742	82
Benton	$3,013,259,730	$18,031,234	0.60%	$14,585,713	$372,029	$32,988,975	$74,163	$33,063,138	17	3	396	68
Bollinger	$1,055,266,200	$4,685,700	0.44%	$2,586,700	$340,000	$7,612,400	$37,820,000	$45,432,400	186	26	1,057	169
Boone	$22,459,358,509	$239,220,525	1.07%	$229,775,130	$3,241,270	$472,236,925	$2,491,133	$474,728,058	963	130	7,338	4,487
Buchanan	$12,861,829,289	$130,419,155	1.01%	$229,736,225	$22,797,091	$382,952,471	$1,024,903	$383,977,374	333	153	1,681	856
Butler	$5,038,326,161	$141,003,736	2.80%	$147,138,562	$4,702,637	$292,844,935	$882,656	$293,727,591	738	91	5,012	2,819
Caldwell	$1,196,452,770	$2,537,333	0.21%	$2,410,892	$60,789	$5,009,014	$12,158	$5,021,172	0	0	116	0
Callaway	$5,362,130,935	$41,859,306	0.78%	$44,634,932	$2,031,568	$88,525,807	$165,346	$88,691,153	72	3	1,477	377
Camden	$10,122,515,193	$114,932,549	1.14%	$125,233,853	$5,264,328	$245,430,730	$948,308	$246,379,038	454	43	1,510	339
Cape Girardeau	$8,837,960,200	$20,269,400	0.23%	$27,413,400	$6,330,000	$54,012,800	$400,277,200	$454,290,000	399	48	2,527	964
Carroll	$1,458,861,868	$37,370,646	2.56%	$45,044,650	$4,172,557	$86,587,853	$115,499	$86,703,353	20	0	686	81
Carter	$516,431,400	$6,591,900	1.28%	$3,287,100	$200,000	$10,079,000	$60,691,000	$70,770,000	164	86	1,172	126
Cass	$13,279,914,156	$65,030,858	0.49%	$46,918,167	$1,107,576	$113,056,600	$173,857	$113,230,457	239	1	2,878	897
Cedar	$3,068,392,700	$900,000	0.03%	$550,000	$70,000	$1,520,000	$390,000	$1,910,000	18	0	40	1
Chariton	$1,141,320,794	$20,926,006	1.83%	$11,988,807	$175,072	$33,089,885	$66,868	$33,156,753	57	0	737	128
Christian	$7,529,478,300	$161,400	0.00%	$92,500	$1,420,000	$1,673,900	$137,436,100	$139,110,000	3	1	2,285	777
Clark	$863,202,602	$9,855,113	1.14%	$6,962,772	$116,715	$16,934,600	$25,531	$16,960,131	2	0	300	32
Clay	$33,542,252,386	$201,154,453	0.60%	$161,383,856	$3,393,242	$365,931,551	$842,536	$366,774,087	695	204	4,992	2,989
Clinton	$2,775,443,431	$10,358,446	0.37%	$6,587,096	$59,573	$17,005,115	$6,079	$17,011,194	20	0	524	76
Cole	$13,038,367,843	$140,899,179	1.08%	$143,274,813	$2,683,227	$286,857,218	$2,001,174	$288,858,392	328	123	3,347	2,267
Cooper	$2,184,855,184	$36,760,325	1.68%	$26,837,128	$801,199	$64,398,652	$97,262	$64,495,915	28	8	854	115
Crawford	$2,509,015,500	$9,948,600	0.40%	$6,414,400	$1,130,000	$17,493,000	$159,717,000	$177,210,000	335	20	1,922	328
Dade	$898,024,974	$3,435,794	0.38%	$2,413,323	$91,184	$5,940,301	$13,374	$5,953,675	0	0	175	1
Dallas	$1,651,956,915	$16,819,101	1.02%	$8,909,236	$139,815	$25,868,152	$14,589	$25,882,741	38	14	775	68
Daviess	$1,165,449,164	$12,871,463	1.10%	$21,233,598	$3,320,295	$37,425,357	$35,258	$37,460,614	15	0	214	4
DeKalb	$1,325,324,237	$5,357,943	0.40%	$4,266,172	$111,852	$9,735,966	$8,510	$9,744,477	2	0	184	7
Dent	$1,504,374,500	$3,970,800	0.26%	$4,755,500	$260,000	$8,986,300	$53,643,700	$62,630,000	156	20	933	218
Douglas	$1,032,483,300	$1,240,800	0.12%	$731,800	$710,000	$2,682,600	$655,422,000	$658,104,600	118	13	895	185
Dunklin	$2,955,358,900	$1,501,500	0.05%	$1,139,100	$540,000	$3,180,600	$137,319,400	$140,500,000	152	3	963	382
Franklin	$12,364,369,900	$17,528,300	0.14%	$10,115,600	$2,030,000	$29,673,900	$178,166,100	$207,840,000	153	88	2,259	482
Gasconade	$1,996,743,400	$40,673,100	2.04%	$34,134,900	$840,000	$75,648,000	$57,172,000	$132,820,000	600	170	1,314	218
Gentry	$838,279,112	$4,148,241	0.49%	$3,862,533	$217,625	$8,228,399	$8,510	$8,236,910	1	0	139	5
Greene	$39,034,723,450	$43,724,313	0.11%	$34,920,850	$1,326,416	$79,971,579	$151,973	$80,123,551	76	3	1,282	396
Grundy	$1,428,909,911	$6,505,639	0.46%	$6,764,600	$172,641	$13,442,880	$19,452	$13,462,332	2	0	201	19

County	Countywide Building Exposure	Structural Damage	Loss Ratio	Contents Loss	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	# Hazus UDF damaged structures	#Substantially damaged	# Displaced People	# Shelter Needs
Harrison	$1,058,298,500	$772,700	0.07%	$425,700	$240,000	$1,438,400	$30,211,600	$31,650,000	42	4	849	49
Henry	$3,084,307,484	$41,159,017	1.33%	$33,495,955	$564,122	$75,219,094	$322,182	$75,541,276	100	14	1,351	403
Hickory	$867,154,100	$29,741,300	3.43%	$33,445,800	$70,000	$63,257,100	$206,051,000	$269,308,100	568	486	455	163
Holt	$635,925,400	$22,267,300	3.50%	$15,261,700	$57,590,000	$95,119,000	$251,661,000	$346,780,000	1,908	131	386	4
Howard	$1,320,874,482	$18,025,155	1.36%	$19,706,578	$955,603	$38,687,336	$62,005	$38,749,341	36	0	460	148
Howell	$3,535,328,200	$28,880,000	0.82%	$54,710,000	$10,990,000	$94,580,000	$157,090,000	$251,670,000	38	0	156	32
Iron	$1,189,869,322	$10,251,457	0.86%	$8,353,625	$131,304	$18,736,386	$12,158	$18,748,544	31	2	465	114
Jackson	$108,581,199,794	$896,418,928	0.83%	$1,269,692,575	$64,894,690	$2,231,006,194	$13,666,583	$2,244,672,777	1,264	380	7,075	4,426
Jasper	$14,675,052,130	$75,389,304	0.51%	$70,676,940	$2,419,402	$148,485,646	$750,136	$149,235,782	393	3	3,958	1,627
Jefferson	$27,050,823,506	$447,292,766	1.65%	$330,408,890	$7,435,711	$785,137,367	$2,147,068	$787,284,434	2,214	540	13,463	8,981
Johnson	$7,348,793,306	$36,772,483	0.50%	$31,299,041	$834,025	$68,905,549	$121,578	$69,027,127	102	5	1,851	428
Knox	$533,025,926	$4,065,568	0.76%	$2,624,869	$41,337	$6,731,774	$2,432	$6,734,206	10	0	199	10
Laclede	$3,913,086,490	$37,253,932	0.95%	$46,295,688	$2,192,051	$85,741,671	$284,493	$86,026,163	37	2	1,285	236
Lafayette	$4,670,288,879	$17,061,041	0.37%	$15,096,341	$524,001	$32,681,383	$47,415	$32,728,798	6	0	568	23
Lawrence	$4,250,075,182	$27,679,664	0.65%	$31,525,176	$1,279,001	$60,483,840	$345,282	$60,829,122	135	1	1,828	422
Lewis	$1,210,762,501	$17,710,268	1.46%	$12,529,829	$229,782	$30,469,879	$272,335	$30,742,214	11	2	480	85
Lincoln	$5,738,385,674	$90,193,857	1.57%	$60,623,655	$1,736,134	$152,553,646	$164,130	$152,717,776	341	101	2,252	1,008
Linn	$1,886,629,207	$8,227,183	0.44%	$6,036,348	$204,251	$14,467,782	$19,452	$14,487,235	13	0	277	61
Livingston	$2,080,345,517	$14,399,699	0.69%	$22,115,039	$1,558,630	$38,073,367	$127,657	$38,201,024	25	0	320	100
Macon	$1,987,602,170	$6,065,527	0.31%	$4,527,565	$200,604	$10,793,695	$7,295	$10,800,990	3	0	290	10
Madison	$1,380,642,229	$36,715,341	2.66%	$49,507,778	$2,595,690	$88,818,810	$211,546	$89,030,355	87	8	1,256	347
Maries	$980,656,500	$13,085,600	1.33%	$7,409,300	$130,000	$20,624,900	$12,415,100	$33,040,000	180	112	524	111
Marion	$3,920,454,117	$49,614,767	1.27%	$45,911,501	$2,572,591	$98,098,859	$115,499	$98,214,358	86	43	867	180
McDonald	$1,672,554,300	$188,740,000	11.28%	$224,490,000	$26,640,000	$439,870,000	$374,700,000	$814,570,000	242	141	1,648	204
Mercer	$488,159,996	$7,534,189	1.54%	$9,205,886	$520,354	$17,260,429	$68,084	$17,328,513	10	0	166	23
Miller	$2,923,309,029	$36,411,396	1.25%	$19,803,841	$313,671	$56,528,908	$62,005	$56,590,913	213	15	708	193
Mississippi	$1,090,352,700	$13,145,600	1%	$8,119,400	$53,062,310	$74,327,310	$56,939,000	$131,266,310	460	102	3,139	185
Moniteau	$1,833,466,794	$17,884,124	0.98%	$12,048,380	$344,066	$30,276,570	$20,668	$30,297,238	8	0	536	48
Monroe	$1,190,838,298	$7,225,381	0.61%	$5,077,097	$125,225	$12,427,703	$10,942	$12,438,645	1	0	204	8
Montgomery	$1,458,917,500	$1,078,300	0.07%	$612,200	$660,000	$2,350,500	$40,529,500	$42,880,000	158	11	593	66
Morgan	$3,492,078,888	$55,258,418	1.58%	$30,178,092	$359,871	$85,796,381	$227,351	$86,023,731	707	34	896	217
New Madrid	$1,766,917,400	$12,061,000	$0	$6,246,100	$8,323,539	$26,630,639	$64,035,000	$90,665,639	292	159	3,878	247
Newton	$6,698,344,914	$66,794,955	1.00%	$71,442,882	$3,007,840	$141,245,676	$438,897	$141,684,573	412	18	3,796	1,615
Nodaway	$2,975,986,346	$12,270,868	0.41%	$20,271,916	$1,128,244	$33,671,028	$199,388	$33,870,416	4	0	239	3
Oregon	$888,766,700	$16,420,000	1.85%	$19,350,000	$2,830,000	$38,600,000	$29,400,000	$68,000,000	36	5	132	31
Osage	$1,959,582,087	$50,843,921	2.59%	$24,928,354	$125,225	$75,897,500	$100,910	$75,998,409	112	63	1,090	242
Ozark	$919,170,900	$13,030,000	1.42%	$20,690,000	$3,970,000	$37,690,000	$34,460,000	$72,150,000	4	1	141	27
Pemiscot	$1,631,806,200	$7,589,300	0.5%	$4,904,800	$3,052,492	$15,546,592	$51,094,000	$66,640,592	211	59	3,733	252
Perry	$2,198,745,400	$49,556,400	2.25%	$56,530,300	$680,000	$106,766,700	-$44,226,700	$62,540,000	772	570	817	202
Pettis	$4,478,988,700	$2,488,800	0.06%	$1,657,200	$710,000	$4,856,000	$51,504,000	$56,360,000	72	20	1,357	271
Phelps	$4,876,789,900	$11,385,500	0.23%	$6,059,200	$380,000	$17,824,700	$146,795,300	$164,620,000	242	79	2,480	596

County	Countywide Building Exposure	Structural Damage	Loss Ratio	Contents Loss	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	# Hazus UDF damaged structures	#Substantially damaged	# Displaced People	# Shelter Needs
Pike	$2,263,269,348	$29,177,505	1.29%	$25,660,253	$1,283,864	$56,121,622	$74,163	$56,195,784	143	48	486	64
Platte	$13,811,465,341	$92,964,620	0.67%	$90,962,230	$3,351,906	$187,278,755	$741,626	$188,020,381	255	15	1,709	794
Polk	$3,293,188,218	$18,708,423	0.57%	$16,230,663	$330,692	$35,269,779	$145,894	$35,415,672	51	2	1,171	165
Pulaski	$6,485,773,071	$96,774,874	1.49%	$59,032,199	$662,600	$156,469,674	$227,351	$156,697,024	260	137	2,051	1,314
Putnam	$646,819,289	$4,472,855	0.69%	$2,593,259	$103,341	$7,169,455	$3,647	$7,173,102	5	0	169	7
Ralls	$1,405,011,323	$53,704,651	3.82%	$72,859,265	$6,568,859	$133,132,776	$104,557	$133,237,333	33	5	598	142
Randolph	$2,948,467,166	$4,989,561	0.17%	$3,606,004	$109,420	$8,704,985	$15,805	$8,720,790	3	0	227	7
Ray	$3,084,500,793	$42,510,964	1.38%	$34,319,039	$761,078	$77,591,081	$218,840	$77,809,922	289	0	2,034	712
Reynolds	$705,096,600	$3,133,100	0.44%	$2,076,200	$2,090,000	$7,299,300	$124,440,700	$131,740,000	260	23	1,556	131
Ripley	$1,375,454,495	$35,398,651	2.57%	$25,880,309	$672,326	$61,951,287	$267,472	$62,218,759	129	88	782	344
Saline	$2,963,641,316	$18,105,396	0.61%	$10,822,874	$108,204	$29,036,474	$21,884	$29,058,358	14	0	578	74
Schuyler	$488,500,414	$2,333,082	0.48%	$987,213	$2,432	$3,322,727	$0	$3,322,727	3	0	104	3
Scotland	$658,329,079	$3,839,433	0.58%	$3,231,543	$59,573	$7,130,550	$23,100	$7,153,650	3	0	136	6
Scott	$4,907,238,328	$46,774,705	0.95%	$54,718,612	$3,458,894	$104,952,211	$629,774	$105,581,985	535	33	3,276	1,812
Shannon	$718,180,000	$5,739,400	0.80%	$4,342,800	$190,000	$10,272,200	$176,379,000	$186,651,200	262	65	766	131
Shelby	$956,359,315	$5,903,828	0.62%	$10,621,054	$655,305	$17,180,188	$10,942	$17,191,130	0	0	99	1
St. Charles	$50,874,321,246	$481,474,421	0.95%	$449,538,312	$17,902,361	$948,915,094	$3,897,791	$952,812,885	1,958	410	9,257	5,933
St. Clair	$1,001,761,600	$660,900	0.07%	$476,400	$140,000	$1,277,300	$84,861,292	$86,138,592	38	6	561	107
St. Francois	$7,513,722,377	$59,046,788	0.79%	$49,601,393	$1,502,704	$110,150,886	$337,987	$110,488,873	184	32	2,352	877
St. Louis	$151,410,414,800	$308,785,700	0.20%	$429,150	$49,230,000	$358,444,850	$2,923,205,150	$3,281,650,000	3,893	705	23,441	5,366
St. Louis City	$49,110,808,300	$21,854,700	0.04%	$23,655,100	$3,020,000	$48,529,800	$227,500,200	$276,030,000	520	17	2,941	449
Ste. Genevieve	$2,629,907,267	$32,464,974	1.23%	$29,187,231	$1,288,727	$62,940,932	$117,931	$63,058,863	43	12	808	215
Stoddard	$2,984,936,400	$1,437,800	0.05%	$843,500	$311,190	$2,592,490	$119,891,000	$122,483,490	218	8	4,457	364
Stone	$3,824,255,800	$127,754,700	3.34%	$165,933	$1,090,000	$129,010,633	$50,549,367	$179,560,000	2,214	1,821	1,444	371
Sullivan	$759,379,851	$4,875,278	0.64%	$8,059,406	$769,589	$13,704,272	$34,042	$13,738,314	6	0	208	11
Taney	$7,441,317,813	$129,755,339	1.74%	$104,846,438	$1,727,623	$236,329,400	$633,421	$236,962,822	517	189	2,558	1,508
Texas	$2,296,763,100	$2,788,800	0.12%	$1,496,700	$400,000	$4,685,500	$97,584,500	$102,270,000	197	45	1,989	393
Vernon	$2,737,207,149	$9,557,247	0.35%	$4,323,314	$24,316	$13,904,876	$3,647	$13,908,523	17	5	369	98
Warren	$3,650,285,200	$7,087,500	0.19%	$9,260,800	$1,120,000	$17,468,300	$69,061,700	$86,530,000	535	22	1,227	325
Washington	$2,104,498,203	$10,895,821	0.52%	$6,119,021	$148,325	$17,163,167	$12,158	$17,175,324	12	4	431	58
Wayne	$1,527,737,022	$114,537,420	7.50%	$92,889,241	$3,295,980	$210,722,641	$487,528	$211,210,169	614	367	2,927	1,397
Webster	$2,725,194,800	$1,316,300	0.05%	$697,400	$1,180,000	$3,193,700	$8,286,300	$11,480,000	42	15	187	83
Worth	$327,691,622	$1,965,916	0.60%	$968,977	$20,668	$2,955,561	$0	$2,955,561	0	0	57	0
Wright	$1,948,082,024	$7,187,692	0.37%	$5,116,002	$108,204	$12,411,898	$18,237	$12,430,135	0	0	221	10
Total	**$820,240,066,166**	**$5,839,407,127**		**$5,443,383,694**	**$461,427,052**	**$11,744,217,875**	**$8,161,218,148**	**$19,905,436,023**	$33,426	**$8,807**	**$192,910**	**$67,684**

Note: Columns headers in dark blue refer to computations within Hazus; column headers in light blue refer to computations performed outside of the Hazus environment.

Table 3.26. B. Total Direct Building Loss and Income Loss to all Counties and the City of St. Louis

County	Residential		Agriculture		Commercial		Education		Government		Industrial		Total # Population Affected	Total Loss - Hazus Layer
	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss		
Adair	101	$12,792,100	9	$872,84	2	$8,286,854	0	$0	0	$0	0	$0	198	$21,951,800
Andrew	211	$55,263,672	145	$38,228,552	14	$9,622,347	0	$0	15	$13,321,909	2	$758,519	540	$117,194,999
Atchison	275	$23,167,325	922	$6,222,591	25	$19,236,856	0	$0	4	$1,416,000	18	$859,828	673	$50,902,600
Audrain	139	$3,288,764	127	$36,155,454	21	$16,591,762	0	$0	6	$4,596,292	3	$4,105,681	356	$64,737,952
Barry	494	$67,448,785	46	$5,436,292	49	$189,264,723	0	$0	4	$514,254	3	$15,659,346	1324	$278,323,400
Barton	145	$30,834,326	291	$80,496,584	60	$46,163,868	1	$2,318,305	2	$1,416,302	10	$17,842,385	344	$179,071,770
Bates	21	$4,515,001	71	$66,867,966	12	$8,684,935	2	$1,148,378	4	$2,422,077	0	$0	51	$83,638,358
Benton	175	$33,616,164	5	$5,616,036	1292	$1,031,810,419	0	$0	0	$0	2	$2,305,756	420	$1,073,348,374
Bollinger	156	$32,965,315	30	$12,467,085	0	$0	0	$0	0	$0	0	$0	157	$45,432,400
Boone	775	$245,940,532	162	$59,014,042	24	$26,022,891	5	$19,599,597	12	$15,296,065	0	$0	1852	$365,873,127
Buchanan	632	$172,253,957	639	$188,551,456	69	$80,200,962	6	$8,440,173	113	$121,518,211	507	$801,830,890	1593	$1,372,795,649
Butler	3185	$710,907,732	2153	$918,994,250	240	$193,251,287	14	$27,473,744	23	$23,882,953	131	$137,965,004	8090	$2,012,474,969
Caldwell	1	$224,916	58	$13,599,470	0	$0	0	$0	0	$0	0	$0	2	$13,824,385
Callaway	207	$53,061,005	284	$66,865,094	37	$28,234,482	4	$8,040,409	15	$11,764,776	37	$28,090,907	530	$196,056,674
Camden	1122	$306,575,051	76	$22,128,501	14992	$14,704,590,798	0	$0	8	$7,504,098	3	$2,416,348	3142	$15,043,214,795
Cape Girardeau	294	$75,724,060	83	$67,635,858	12	$126,427,576	0	$0	0	$0	10	$20,785,306	2527	$290,572,800
Carroll	164	$39,831,344	1437	$1,129,038,074	12	$9,607,993	0	$0	21	$19,720,237	25	$35,723,326	405	$1,233,920,975
Carter	158	$34,827,742	6	$16,831,258	0	$0	0	$0	0	$0	0	$0	1172	$51,659,000
Cass	162	$50,718,733	264	$86,846,275	67	$44,417,950	0	$0	0	$0	27	$14,971,689	418	$196,954,647
Cedar	13	$1,450,000	1	$70,000	2	$220,000	0	$0	0	$0	2	$170,000	40	$1,910,000
Chariton	201	$44,663,170	650	$811,096,373	30	$22,541,400	0	$0	0	$0	1	$749,583	543	$879,050,527
Christian	3	$53,163,900	0	$0	0	$0	0	$0	0	$0	0	$0	2285	$53,163,900
Clark	92	$19,012,081	196	$172,193,084	16	$10,363,309	0	$0	2	$1,037,990	0	$0	232	$202,606,464
Clay	551	$183,637,947	192	$54,891,063	143	$183,668,088	1	$2,345,440	14	$19,085,373	65	$88,084,432	1449	$531,712,343
Clinton	31	$8,880,574	16	$3,454,801	69	$40,459,970	0	$0	0	$0	0	$0	76	$52,795,344
Cole	234	$74,481,569	153	$42,248,670	16	$15,557,762	4	$7,723,027	11	$18,804,210	19	$14,649,716	557	$173,464,955
Cooper	47	$11,288,679	119	$32,458,418	127	$81,060,139	0	$0	0	$0	5	$4,229,644	118	$129,036,880
Crawford	321	$51,449,131	3	$14,244,065	10	$48,925,467	0	$0	1	$94,336	0	$0	1922	$114,713,000
Dade	19	$3,479,999	16	$9,269,107	30	$18,030,103	0	$0	1	$397,632	0	$0	46	$31,176,840
Dallas	39	$7,323,368	64	$27,436,782	0	$0	0	$0	1	$619,318	0	$0	103	$35,379,468

County	Residential		Agriculture		Commercial		Education		Government		Industrial		Total # Population Affected	Total Loss - Hazus Layer
	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss		
Daviess	40	$8,983,797	239	$58,492,425	459	$254,308,933	0	$0	1	$340,793	4	$4,368,814	107	$326,494,762
DeKalb	70	$20,056,047	30	$7,491,968	10	$74,088,395	0	$0	0	$0	0	$0	168	$101,636,410
Dent	83	$178,404,938	45	$4,099,206	28	$17,892,156	0	$0	0	$0	0	$0	933	$200,396,300
Douglas	84	$144,923,939	33	$100,400,621	1	$412,780,041	0	$0	0	$0	0	$0	895	$658,104,600
Dunklin	148	$55,467,438	3	$16,532,262	1	$41,670,900	0	$0	0	$0	0	$0	963	$113,670,600
Franklin	133	$61,710,534	12	$9,820,692	8	$36,102,673	0	$0	0	$0	0	$0	2259	$107,633,900
Gasconade	462	$66,270,776	72	$7,336,237	66	$39,800,987	0	$0	0	$0	0	$0	1314	$113,408,000
Gentry	24	$4,828,582	28	$17,019,079	69	$52,505,183	0	$0	3	$2,795,426	1	$543,868	60	$77,692,139
Greene	532	$158,411,652	235	$72,541,256	180	$187,802,345	6	$13,650,778	29	$33,048,143	43	$43,567,563	1181	$509,021,737
Grundy	21	$4,921,093	135	$34,872,337	3	$2,200,477	0	$0	11	$8,277,411	0	$0	52	$50,271,318
Harrison	36	$22,385,310	6	$4,203,090	0	$0	0	$0	0	$0	0	$0	849	$26,588,400
Henry	52	$11,425,402	161	$55,088,208	35	$27,206,806	0	$0	11	$10,300,165	33	$43,416,720	120	$147,437,301
Hickory	186	$195,288,371	0	$0	380	$71,767,413	0	$0	0	$0	2	$2,251,316	455	$269,307,100
Holt	706	$59,065,990	1149	$66,349,647	34	$59,390,773	0	$0	14	$577,691	5	$1,094,899	386	$186,479,000
Howard	124	$29,429,939	118	$31,057,255	61	$31,333,969	2	$2,215,363	1	$796,264	1	$522,321	332	$95,355,110
Howell	2	$6,430,000	9	$50,060,000	27	$195,180,000	0	$0	0	$0	0	$0	156	$251,670,000
Iron	306	$58,373,417	384	$130,053,724	10	$6,070,382	0	$0	2	$1,316,447	22	$29,622,195	734	$225,436,165
Jackson	1123	$361,402,825	218	$76,983,335	1095	$1,479,301,745	2	$5,403,213	1	$1,738,437	598	$865,030,631	2684	$2,789,860,185
Jasper	605	$144,151,974	282	$106,773,976	140	$130,945,985	3	$8,431,130	5	$5,850,772	28	$32,204,635	1555	$428,358,473
Jefferson	4809	$1,165,213,044	653	$6,481,741	752	$368,240,179	13	$26,986,591	19	$16,831,781	163	$295,993,755	12648	$1,879,747,091
Johnson	149	$42,529,210	57	$14,008,757	6	$4,623,974	3	$24,388,453	0	$0	7	$6,557,904	370	$92,108,298
Knox	0	$0	22	$33,738,457	4	$2,436,099	0	$0	0	$0	4	$1,559,359	0	$37,733,915
Laclede	66	$199,469	119	$264,680	22	$806,218	0	$0	0	$0	18	$1,044,895	164	$2,315,262
Lafayette	25	$6,759,123	103	$15,055,124	13	$10,680,186	0	$0	0	$0	1	$724,442	61	$33,218,875
Lawrence	274	$59,120,227	116	$54,925,842	60	$37,771,689	0	$0	16	$9,142,666	16	$17,291,964	696	$178,252,387
Lewis	120	$26,859,070	297	$257,880,356	29	$16,637,876	0	$0	4	$1,973,403	30	$29,077,717	292	$332,428,423
Lincoln	830	$230,004,400	804	$2,632,966	43	$83,103,343	0	$0	1	$1,671,272	0	$0	2399	$317,411,981
Linn	53	$12,140,214	111	$12,140,214	22	$15,993,357	0	$0	1	$763,791	0	$0	124	$41,037,576
Livingston	13	$3,075,939	56	$17,689,048	2	$1,955,261	0	$0	0	$0	0	$0	30	$22,720,249
Macon	63	$13,260,677	243	$60,972,164	14	$10,064,158	0	$0	0	$0	0	$0	161	$84,296,998
Madison	196	$36,466,667	130	$37,951,302	77	$55,381,416	0	$0	3	$2,128,679	4	$3,772,434	466	$135,700,499
Maries	141	$22,837,804	32	$657,636	7	$3,059,460	0	$0	0	$0	0	$0	524	$26,554,900

County	Residential		Agriculture		Commercial		Education		Government		Industrial		Total # Population Affected	Total Loss - Hazus Layer
	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss		
Marion	493	$131,908,448	128	$34,574,838	78	$58,623,108	0	$0	10	$8,715,182	12	$11,783,610	1154	$245,605,185
McDonald	222	$355,200,000	0	$0	14	$339,150,000	0	$0	0	$0	6	$120,220,000	1648	$814,570,000
Mercer	1	$294,344	18	$16,410,295	0	$0	0	$0	0	$0	0	$0	3	$16,704,639
Miller	252	$51,576,179	149	$43,635,080	996	$653,124,735	0	$0	6	$3,793,234	5	$3,248,522	620	$755,377,750
Mississippi	228	$48,657,384	232	$30,832,616	0	$0	0	$0	0	$0	0	$0	3139	$79,490,000
Moniteau	38	$9,397,903	134	$35,248,932	2	$1,165,988	0	$0	3	$3,197,805	0	$0	103	$49,010,628
Monroe	84	$16,994,074	69	$25,623,375	20	$9,562,922	0	$0	0	$0	0	$0	192	$52,180,371
Montgomery	54	$6,371,900	104	$5,425,600	0	$0	0	$0	0	$0	0	$0	593	$11,797,500
Morgan	574	$111,061,288	96	$26,023,324	5813	$4,097,621,112	0	$0	0	$0	3	$1,722,940	1504	$4,236,428,664
New Madrid	267	$73,314,568	25	$55,235,529	0	$0	0	$0	0	$0	0	$0	3878	$128,550,097
Newton	832	$182,218,466	208	$47,244,089	202	$156,031,293	11	$42,704,304	5	$4,519,023	17	$13,734,360	2138	$446,451,536
Nodaway	12	$3,532,128	52	$19,327,275	3	$2,285,510	0	$0	2	$1,429,323	0	$0	27	$26,574,236
Oregon	31	$24,320,000	0	$0	5	$43,680,000	0	$0	0	$0	0	$0	132	$68,000,000
Osage	254	$62,798,908	468	$360,147,912	47	$36,464,041	0	$0	1	$817,076	30	$56,663,806	660	$516,891,743
Ozark	1	$21,190,000	0	$0	2	$30,650,000	0	$0	0	$0	1	$20,310,000	141	$72,150,000
Pemiscot	198	$28,179,770	8	$17,149,209	0	$0	0	$0	4	$1,021,562	1	$17,410,559	3733	$63,761,100
Perry	300	$29,648,315	436	$9,266,740	36	$86,891,646	0	$0	0	$0	0	$0	817	$125,806,700
Pettis	62	$16,281,479	5	$12,543,250	3	$66,686	0	$0	2	$336,586	0	$0	1357	$29,228,000
Phelps	235	$33,679,085	4	$14,536,427	3	$57,199,188	0	$0	0	$0	0	$0	248	$105,414,700
Pike	341	$81,485,913	126	$714,415	111	$47,744,717	0	$0	2	$2,749,859	19	$6,027,708	839	$138,722,612
Platte	181	$67,728,912	109	$33,047,061	82	$86,757,405	0	$0	26	$37,513,793	42	$46,042,048	460	$271,089,219
Polk	39	$8,174,347	47	$13,028,299	14	$8,555,685	0	$0	3	$2,612,306	3	$1,323,926	101	$33,694,562
Pulaski	202	$350,125	132	$243,326	13	$777,167	4	$1,458,439	0	$0	2	$630,511	574	$3,459,568
Putnam	2	$363,320	18	$16,703,601	0	$0	0	$0	0	$0	10	$8,611,100	5	$25,678,021
Ralls	99	$22,304,125	172	$44,760,631	30	$15,091,494	0	$0	5	$4,128,181	24	$37,843,161	248	$124,127,592
Randolph	15	$3,303,928	7	$4,044,016	12	$9,603,330	0	$0	2	$1,765,077	0	$0	39	$18,716,351
Ray	318	$87,699,243	502	$222,315,498	22	$14,868,684	0	$0	4	$3,378,321	11	$10,671,314	811	$338,933,060
Reynolds	237	$18,530,061	19	$14,327,535	2	$15,280,545	0	$0	0	$0	2	$14,327,158	1556	$62,465,300
Ripley	239	$40,233,255	137	$228,632	26	$21,012,457	0	$0	0	$0	2	$4,345,441	638	$65,819,785
Saline	88	$24,268,973	205	$105,796,550	5	$3,857,894	0	$0	0	$0	2	$1,310,922	230	$135,234,338
Schuyler	0	$0	20	$17,409,970	0	$0	0	$0	0	$0	0	$0	0	$17,409,970
Scotland	1	$221,267	14	$16,734,969	10	$8,339,193	0	$0	1	$1,755,493	0	$0	3	$27,050,922

County	Residential		Agriculture		Commercial		Education		Government		Industrial		Total # Population Affected	Total Loss - Hazus Layer
	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss		
Scott	2260	$68,319,424	937	$311,460,268	85	$68,319,424	0	$0	7	$6,427,461	23	$25,743,095	5650	$480,269,670
Shannon	204	$168,636,157	27	$7,800,017	30	$9,990,933	0	$0	1	$225,093	0	$0	766	$186,652,200
Shelby	7	$1,565,622	31	$9,231,472	3	$1,476,499	0	$0	0	$0	0	$0	17	$12,273,593
St. Charles	4342	$1,575,046,025	2199	$39,222,924	957	$1,002,348,556	6	$18,755,483	52	$97,499,600	182	$475,655,361	11463	$3,208,527,949
St. Clair	32	$62,720,601	5	$4,646,088	1	$4,560,611	0	$0	0	$0	0	$0	561	$71,927,300
St. Francois	268	$69,282,414	47	$463,984	360	$176,258,262	0	$0	6	$1,813,757	14	$16,949,807	641	$264,768,223
St. Louis	2795	$557,295,122	94	$313,506,017	875	$562,784,265	2	$2,009,433	16	$10,696,584	111	$484,520,979	23441	$1,930,812,400
St. Louis City	491	$28,091,396	1	$67,818	14	$75,767,777	0	$0	4	$6,181,056	10	$77,701,753	2941	$187,809,800
Ste. Genevieve	531	$131,249,871	274	$707,478	35	$42,785,777	0	$0	0	$0	34	$29,288,631	1312	$204,031,758
Stoddard	211	$62,221,975	7	$60,644,325	0	$0	0	$0	0	$0	0	$0	4457	$122,866,300
Stone	219	$21,612,250	103	$14,148,316	1888	$298,492,066	1	$417,290	1	$127,923	2	$14,797,055	1444	$349,594,900
Sullivan	3	$543,354	8	$2,692,173	11	$6,648,123	0	$0	0	$0	2	$1,640,308	8	$11,523,959
Taney	1095	$291,158,399	1136	$290,308,518	447	$381,434,081	4	$5,730,556	25	$21,519,306	16	$6,919,913	2628	$997,070,773
Texas	165	$154,556,959	29	$11,245,242	3	$14,963,299	0	$0	0	$0	0	$0	1989	$180,765,500
Vernon	12	$2,754,254	32	$24,669,510	0	$0	0	$0	0	$0	0	$0	29	$27,423,764
Warren	161	$17,309,615	366	$10,131,071	8	$17,032,614	0	$0	0	$0	0	$0	1227	$44,473,300
Washington	117	$22,953,855	221	$144,381	30	$7,946,726	0	$0	4	$1,269,491	4	$1,685,281	301	$33,999,734
Wayne	576	$94,218,009	461	$128,878,017	33	$20,930,749	9	$11,213,382	0	$0	0	$0	1388	$255,240,158
Webster	38	$4,040,883	4	$3,402,817	0	$0	0	$0	0	$0	0	$0	187	$7,443,700
Worth	14	$3,181,364	48	$39,548,837	0	$0	0	$0	0	$0	1	$523,627	32	$43,253,828
Wright	3	$598,813	29	$77,532	0	$0	0	$0	0	$0	0	$0	8	$676,344

Figure 3.30. Hazus Countywide Base-Flood Scenarios: Building Exposure

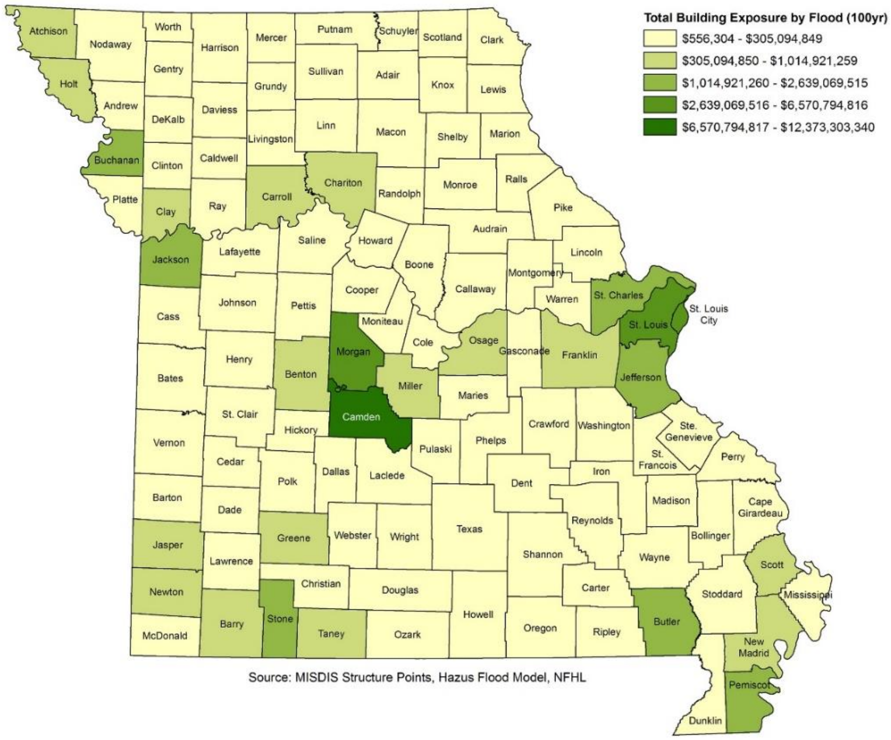


Figure 3.31. Hazus Countywide Base-Flood Scenarios: Building Impacted Ratio

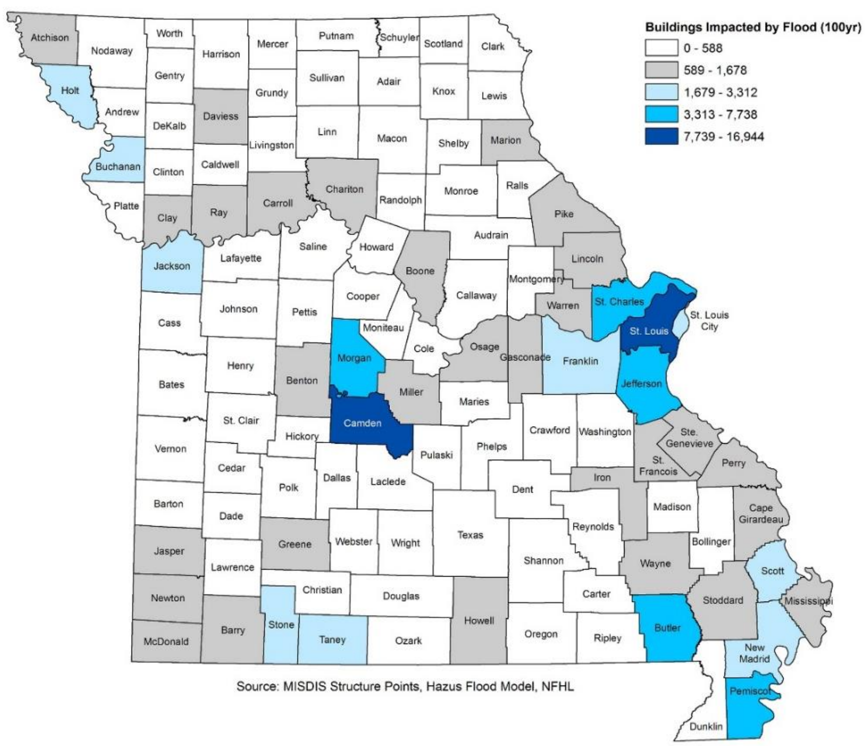
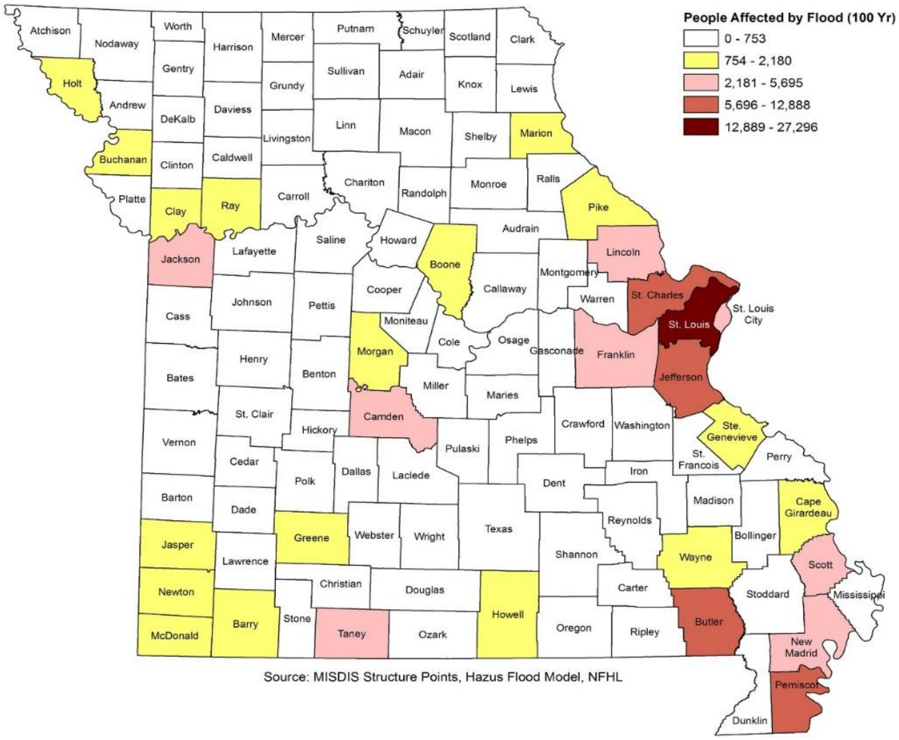


Figure 3.32. Hazus Countywide Base-Flood Scenarios: Displaced People



Source: MISDIS Structure Points, Hazus Flood Model, NFHL

Using the GIS Analysis with the FEMA special flood hazard areas and the MSDIS structure points described earlier, it is estimated that more than 43,486 Missouri households are within the special flood hazard area. In addition, thousands of other Missouri residents are at risk to the dangers of flash flooding from rapidly rising creeks and tributaries, storm water runoff, and other similar flooding events. Nationwide, most flood deaths are from flash floods, and nearly half of these fatalities are auto-related, according to the NWS.

Hazus analyzes loss estimates for critical infrastructure and facilities as well, including vehicle losses, utility system losses, essential facility impacts, transportation impacts, as well as agricultural losses. Hazus also provides the results in more detail, and some results, spatially. Project files for each county are available for use by local governments from SEMA by contacting the SHMO.

Levees may not be detected on the computer terrain models for the Hazus only county analysis. Thus, some communities that may be protected from 1-percent-annual-chance flood events from levees may be modeled by Hazus as inundated and the risk may be overestimated. These results, for those counties with levee protection, should be considered as the “worst-case scenario” and may represent losses that could result from a levee breach.

Lastly, it should be noted that the loss estimates previously presented in **Table 3.26** have been adjusted to maintain consistency between the other hazard (earthquakes) modeled using FEMAs Hazus software. Results derived from earthquake runs in Hazus and the flood analysis are aggregated to the census tract level, data which has been updated by FEMA to reflect the 2010 census effort.

Agricultural Losses

Historically the southeast Missouri Bootheel region is where the State's prime agricultural lands are located, in the lowlands of the Mississippi River floodplain. Therefore, historically this area has seen the most dramatic losses from excess moisture/rain and flooding. However, over the past 5 years, the greatest agricultural losses occurred in the northern portion of the state along the Missouri River. Record flooding in this area resulted in $87,283,482 in agricultural losses with 142,999,510 losses realized statewide.

Table 3.27 presents the actual recorded insurance payments due to flood-related crop losses Statewide from 2017-2021 for the top ten counties by total loss. These losses are caused by excess moisture and flooding. Note, from the January 2017 Missouri Crop Insurance Report, the percent of insured crop acreage statewide was 92-percent.

Table 3.27. Recorded USDA Crop Insurance Losses

County	2017	2018	2019	2020	2021	Grand Total
Atchison	$4,856	$975,600	$12,798,464	$167,445	N/A	$13,946,365
Chariton	$1,012,634	$176,767	$9,077,885	$534,641	$2,247,553	$13,049,480
Carroll	$123,693	$172,885	$9,109,083	$767,671	$2,194,701	$12,368,033
Holt	$970	$786,779	$9,834,992	$469,927	$191,518	$11,284,186
Livingston	$502,690	$527,463	$6,287,612	$28,893	$1,368,880	$8,715,538
St Charles	$976,378	$34,668	$6,073,919	$22,030	$182,176	$7,289,171
Saline	$438,217	$15,565	$3,854,469	$622,725	$1,377,526	$6,308,502
Buchanan	$424,469	$487,681	$2,175,033	$303,560	$2,116,371	$5,507,114
Howard	$72,559	$69,351	$4,093,892	$3,068	$883,436	$5,122,305
Johnson	$1,546,812	N/A	$448,977	$1,640,604	$56,396	$3,692,788
Total	**$5,103,278**	**$3,246,758**	**$63,754,327**	**$4,560,565**	**$10,618,556**	**$87,283,482**

Hazard Impact on Future Growth and Development

To determine the jurisdictions that are most vulnerable to flood losses and are also increasing in population and housing units, the top 10 counties at risk to the 1-percent-annual-chance flood event for building loss, loss ratio and displaced population were compared against the top 10 counties experiencing population gains and housing gains. Boone, Clay, Jackson, Jefferson, St. Charles and St. Louis all were in the top 10 counties of population gain, housing gain, and flood vulnerability.

The counties experiencing the most development pressures all participate in the National Flood Insurance Program. Therefore, flood risk should not be increasing; assuming that floodplain ordinances are being effectively implemented and wise use of floodplains is being encouraged.

SEMA's Floodplain Management Section is actively updating mapping to reflect the risk from flooding across the state. Thirty-two counties are currently in the process of being updated. Development pressures is a key factor in the prioritization of counties within the Five-Year Business Plan for funding requests.

Risk Summary

Floods are often accompanied by other types of severe weather, including tornadoes, lightning, and severe thunderstorm activity. These storms also present a danger to life and property, often resulting in many injuries, and in some cases, fatalities. Floodwaters themselves often interact with hazardous materials. This has prompted the evacuation of many citizens near such materials stored in large containers that could break loose or puncture as a result of flood activity.

Public health concerns that may result from flooding include the need for disease and injury surveillance, community sanitation to evaluate flood-affected food supplies, private water and sewage sanitation, and vector control (for mosquitoes and other entomology concerns).

Problem Statement:

Using the indicators of Building Loss, Loss Ratio and Displaced Persons and the top ten counties with the highest risk for these indicators, the data suggests that it would be most feasible to spend effort and dollars on mitigating losses in these top ten locations.

Mitigation efforts addressing building loss, such as buyouts, floodproofing and insurance awareness, implementation of higher regulatory standards, adoption of building codes, participation in the CRS Program, and pre-staging of emergency response resources to reduces losses to structures would most likely prove most helpful in St. Louis City and Jackson, St. Charles, Jefferson, Boone, Clay, McDonald, Butler, Cole, and Jackson Counties.

Mitigation efforts for displaced populations such as partnerships with agencies providing temporary housing would most likely prove most effective in St. Louis, Jefferson, St. Charles, Boone, Jackson, Butler, Clay, Stoddard, Jasper, and New Madrid Counties. Additionally, many of these counties also have high social vulnerability ratings. Social vulnerability impacts a community's resilience to flooding as described below:

- **Low income** - Low income and minority residents are more likely to move into high-risk flood zones. In addition, low-income populations have been shown to be less likely to evacuate in response to warning systems. Nature-based infrastructure projects, such as those designed to protect against flooding, often exclude socially vulnerable groups and instead end up displacing lower income residents.
- **Minority** - Minorities may have limited access to information and resources designed to prevent or mitigate flooding risk due to language or cultural differences.

Mitigation efforts addressing loss ratio should focus on a combination of buyouts, floodproofing, insurance awareness, implementation of higher regulatory standards, adoption of building codes, participation in the CRS Program, and pre-staging of emergency response resources would most likely prove helpful for McDonald, Wayne, Ralls, Holt, Hickory, Stone, Butler, Madison, Osage, and Ripley.

In addition to the top ten counties identified has having the highest risk for the indicators of building loss, loss ratio, and displaced persons, those communities with identified repetitive loss and severe repetitive loss properties are also key areas to address with mitigation measures to reduce flood risk.

Flood Risk Products

There are a variety of products available to communities which detail flood risk and which were utilized in the 2018 risk assessment. These products are described below along with source information.

Flood Hazard Information Products (Regulatory)

- **Flood Insurance Rate Map (FIRM)** - The official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.
- **Flood Insurance Study (FIS)** - A Flood Insurance Study (FIS) is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the NFIP, the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables.
- **FIRM Database and National Flood Hazard Layer -** These databases are compilations of digital GIS data representing the same information presented on the FIRMs, and in the FIS report. The GIS data is designed to provide the user with the ability to determine the flood zone, base flood elevation and the floodway status for a particular location in their own mapping software.

Flood Risk Products (Non-Regulatory)

For those communities that have been through the Risk MAP process (see **Figure 3.23**), the following additional flood risk resources are available.

- **Flood Risk Map (FRM)** - The FRM depicts flood risk data for a flood risk project area. Typical maps might show the potential flood losses associated with the 1-percent annual chance flood event for each census block, areas planned for new or revised maps, key watershed features that affect local flood risk and information about potential or successful past projects to reduce flood risk
- **Flood Risk Report (FRR)** - The FRR provides community and watershed specific flood risk information extracted from the Flood Risk Database (FRD), explains the concept of flood risk and identifies useful tools and reference materials. The FRR, used in combination with Flood Risk Map (FRM), is a good tool for communities to use for raising local flood risk awareness
- **Flood Risk Database (FRD)** - The FRD stores all flood risk data for a flood risk project, including the information shown in the Flood Risk Report (FRR) and on the Flood Risk Map (FRM). The FRD provides a wealth of data that may be used to analyze, communicate and visualize flood risk on an ad-hoc basis for a variety of uses. Elements in the FRD include:
  - **Changes Since Last FIRM** shows where the Special Flood Hazard Area (SFHA) has changed since the last effective Flood Insurance Rate Map (FIRM)
  - **Areas of Mitigation Interest** (AOMI) communicates where conditions have contributed to the severity of flooding losses, allowing for better prioritization of flood mitigation efforts and use of funds
  - **Flood Depth and Analysis Grids** communicate the depth and velocity of floodwaters as well as the probability of an area being flooded over time. Available grids include:
    - Water Surface Elevation Grid' (WSEL) which is attributed with the base flood elevation data
    - Percent Annual Chance' grid that uses the WSEL to calculate the percent annual chance of flooding for each grid cell

- '30-Year Percent Chance Flood grid' that represents the percent chance of flooding for a location along a flooding source over a 30-year period (or over the life of the typical mortgage).

- **Flood Risk Assessment Data** provides an assessment of potential financial consequences and other impacts associated with structures located in a SFHA.

Flood Risk Data Sources

- **FEMA Flood Map Service Center (MSC)** - the official online resource for all flood hazard mapping products created under the National Flood Insurance Program (NFIP), including your community's flood map, called a Flood Insurance Rate Map (FIRM). https://msc.fema.gov/portal
- **Missouri Hazard Mitigation Viewer -** 2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.
- **Missouri Hazard Mitigation Viewer User Guide -** A User Guide on how to navigate the Missouri Hazard Mitigation Viewer website and data export features is presented in **Appendix B**.
- **How to Identify Mitigation Actions Using Flood Risk Data and Products** - This User Guide was developed as training material for SEMA Mitigation Workshops in 2017 and assists in identifying mitigation projects using the Risk MAP products. It is included in the 2018 State Hazard Mitigation Plan for Missouri.
- **SEMA Local Mitigation Plan Outline** workshops and training materials will be updated in the summer of 2018 to include how to utilize the Risk MAP data and the Missouri Hazard Mitigation Viewer.

NFIP Community Assistance Program State Support Services Element (CAP-SSE)

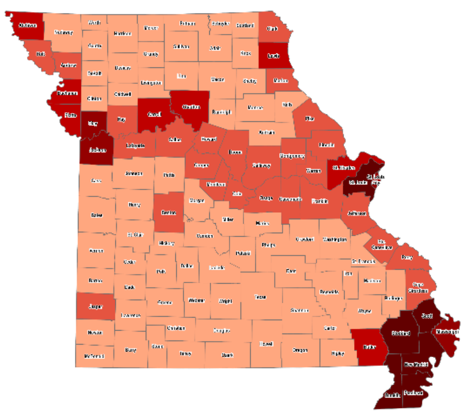
The Community Assistance Program – State Support Services Element (CAP- SSSE) program provides funding to states to provide technical assistance to communities in the National Flood Insurance Program (NFIP) and to evaluate community performance in implementing NFIP floodplain management activities. Examples include:

- Assistance to Communities in Responding to Disasters
- Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs)
- Community Information System (CIS) Entry
- Community Rating System (CRS) Support
- Coordination with Other Programs and Agencies
- Endangered Species Act (ESA) activities
- Enrollment of Communities
- Floodplain Management Regulation Assistance
- General Technical Assistance
- Mapping Coordination Assistance
- Outreach, Workshops and Other Training
- Planning
- Selection of Communities that Receive CACs, CAVs, Trainings, or other Technical Assistance
- State Model Regulation Updates and Monitoring of State Regulatory Environment

3.3.2. Levee Failure

Description

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in loss of life and injuries as well as damages to property, the environment, and the economy.

Vulnerability	Extent/Range of Intensity
	Levee failure can mean either *breaching* or *overtopping* of a levee. A levee breach is when part of the levee structure breaks away leaving an opening for water to rush through. Similar to dam failures, levee failures during flooding events damage assets with the velocity of the water caused by sudden release resulting in a flood surge or flood wave downstream. If the levee is overtopped as a result of flood waters in excess of the levee design, impacts are similar to flood impacts plus water may become trapped behind the levee in unbreeched areas, unable to drain quickly.

Probability	Severity	Location
100% Over 100 events in 80 years	Moderate	Statewide

State Vulnerability Overview

Levees have been constructed across the State of Missouri by public entities and private entities with varying levels of protection, inspection oversight and maintenance. In Missouri, there are currently 182 levee systems in the USACE Levee Safety Program. Of those, 23 are considered to be designed to provide protection from the 1-percent-annual-chance flood event. An additional seven are designed to provide protection from the 0.2-percent-annual-chance flood event. The remaining levees provide protection against lower level flooding that occurs more frequently than the 1-perecent annual chance flood.

Changing Future Conditions Considerations

The impact of changing future conditions on levee failure will most likely be related to changes in precipitation and flood likelihood. Climate change projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on levees and increasing likelihood of levee failure. Furthermore, aging levee infrastructure and a lack of regular maintenance (including checking for seepage and removing trees, roots and other vegetation that can weaken a levee) coupled with more extreme weather events may increase risk of future levee failure.

Risk Summary/Problem Statement

The top five counties most impacted for building loss from levee failure are Pemiscot, Dunklin, New Madrid, Scott and Butler counties. Focusing mitigation efforts and dollars in these five counties would most likely prove the most successful strategy.

Description/Location

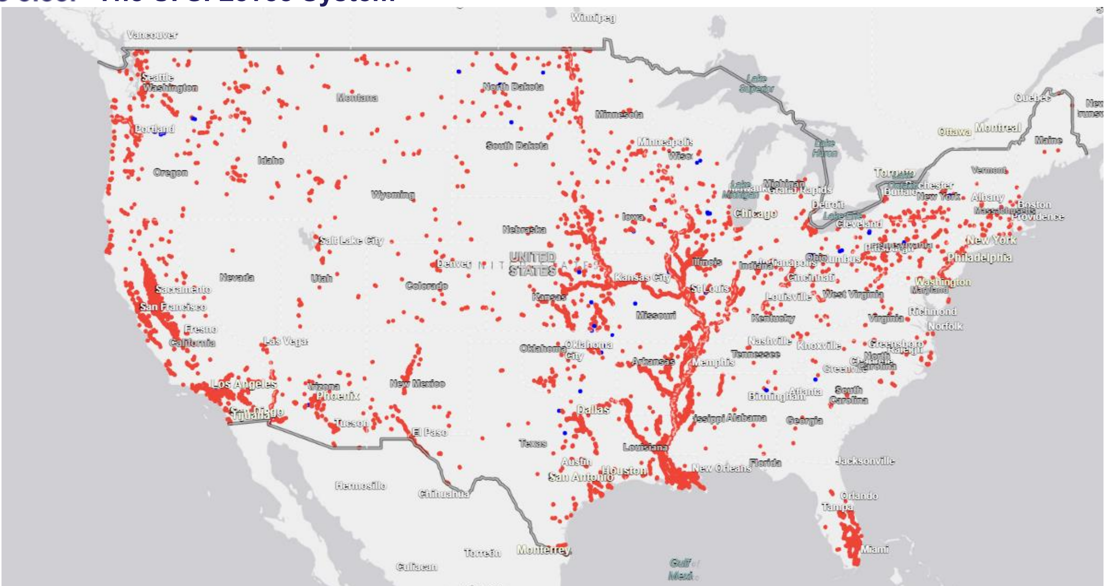
Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Nationwide, approximately 25,000 miles of levees protect communities, infrastructure, and property. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in loss of life and injuries as well as damages to property, the environment, and the economy. Levees are usually engineered to withstand a flood with a computed risk of occurrence.

USACE

The U.S. Army Corps of Engineers (USACE) is tasked nationally with the development and maintenance of the National Levee Database (NLD) which serves as the primary source of information for this risk assessment. The USACE is currently working with States and private owners to perform a national comprehensive Inventory and Review Effort (I&R). The mission of this effort is to collect critical information about each levee similar to the National Inventory of Dams inventory. The current NLD includes information on inspections and risk assessments, levee condition information, identification and characterization of flood risks associated with the levee collected to help inform repair and rehabilitation needs, partners for flood risk management, investments, flood fighting and emergency management activities. The USACE is conducting the I&R effort and one-time inspection for the levees in the inventory as a precursor and key component of a National Levee Safety Program currently authorized, but not funded, by Congress as Title IX of the Water Resources Development Act of 2007, as amended by Section 3016 of the Water Resources Reform and Development Act of 2014.

The USACE is currently working closely with the State of Missouri in I&R effort. The latest version of the NLD includes a previous dataset known as the Missouri Levee Inventory (MLI) and thus supersedes it as a data source. In Missouri, there are an estimated 2,602 miles of levees, many of which were largely constructed to protect agricultural land and are not built to design standards established to protect people and property. Missouri's levee systems are part of the greatest concentration of levees in the lower 48 states as shown in **Figure 3.33** below.

Figure 3.33. The U. S. Levee System



Source: The 2022 USACE National Levee Inventory (NLD) [National Levee Database (army.mil)](https://levees.sec.usace.army.mil/)

The presence of levees can, in some cases, generate a false sense of security. If a larger flood occurs, then that structure will likely be compromised. In the event of a levee failure, the water behind it can be released as flash flood. Failed levees can create floods that are catastrophic to life and property in part because of the tremendous energy of the released water. **Figure 3.34** depicts a levee failure that occurred on the Mississippi River in Winfield, MO in June 2019.

Figure 3.34. 2019 Levee Failure in Missouri

Source: https://www.ksdk.com/article/weather/flooding/mississippi-river-overtops-levee-in-winfield/63-c811997c-9bc7-4ef9-9b27-da7814df11a6

Levees in Missouri in the USACE Levee Safety Program:

In Missouri, there are currently 307 levee systems in the USACE Levee Safety Program. Of those, 23 are considered to be designed to provide protection from the 1-percent-annual-chance flood event. An additional seven are designed to provide protection from the 0.2-percent-annual-chance flood event. The remaining levees provide protection against lower level flooding that occurs more frequently than the 1-perecent annual chance flood. To see the full extent of the NLD or to export the sections of levees for a local analysis, please visit the Missouri Hazard Mitigation Viewer at http://bit.ly/MoHazardMitigationPlanViewer2023 or from the USACE at http://nld.usace.army.mil.

The USACE has developed a levee safety action classification (LSAC) to better inform stakeholders and residents of the levee risk in their communities. The LSAC is neither a levee rating or grade, it is a classification system designed to consider the probability of the levees being loaded (Hazard), existing condition of the levee, the current and future maintenance of the levee (Performance), and the Consequences if a levee were to fail or be overwhelmed (see **Table 3.28**). A levee that reduces risk for a dense population will receive a different classification from an equally constructed levee with a smaller population because the consequences associated with failure is greater.

Table 3.28. Levee Safety Action Classification (LSAC) Table

Risk	Actions for Levee Systems and Leveed Areas	Risk Characteristics of this Class
Very High	Based on risk drivers, take immediate action to implement interim risk reduction measures. Increase frequency of levee monitoring, communicate risk characteristics to the community within an expedited timeframe; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning systems and evacuation procedures; and recommend purchase of flood insurance. Support risk reduction actions as very high priority.	Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in very high risk.
High	Based on risk drivers, implement interim risk reduction measures. Increase frequency of levee monitoring; communicate risk characteristics to the community within an expedited timeframe; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning and evacuation procedures; and recommend purchase of flood insurance. Support risk reduction actions as high priority.	Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in high risk.
Moderate	Based on risk drivers, implement interim risk reduction measures as appropriate. Verify risk information is current and implement routine monitoring program; assure O&M is up to date; communicate risk characteristics to the community in a timely manner; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning and evacuation procedures; and recommend purchase of flood insurance. Support risk reduction actions as a priority.	Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in moderate risk.
Low	Verify risk information is current and implement routine monitoring program and interim risk reduction measures if appropriate; assure O&M is up to date; communicate risk characteristics to the community as appropriate; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning and evacuation procedures; and, recommend purchase of flood insurance. Support risk reduction actions to further reduce risk to as low as practicable.	Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.
Very Low	Continue to implement routine levee monitoring program, including operation and maintenance, inspections, and monitoring of risk. Communicate risk characteristics to the community as appropriate; verify emergency plans and flood inundation maps are current; ensure	Likelihood of inundation due to breach and/or system component malfunction in combination with loss

Risk	Actions for Levee Systems and Leveed Areas	Risk Characteristics of this Class
	community is aware of flood warning and evacuation procedures; and recommend purchase of flood insurance.	of life, economic, or environmental consequences results in very low risk.
No Verdict	Not enough information is available to assign an LSAC.	

Source: www.mvk.usace.army.mil/Portals/58/LSAC_Table.pdf

According to the USACE NLD, there are 16 levee segments within the USACE levee safety program in the state of Missouri that received a high LSAC rating. The levee systems that received a high rating are shown in **Table 3.29.** The full listing of all levees is not added to the table to preserve space in the document but may be extracted from the Missouri Hazard Mitigation Viewer in a CSV format and opened as an Excel table using the procedure described in the Mitigation Viewer User Guide.

Table 3.29. Missouri Levee Segments with LSAC of High

Segment Name	System Name	USACE District	Source	County
City of Hickman Levee and Floodwall	Hickman KY - Obion River System	Memphis	Mississippi River	Mississippi, New Madrid, Pemiscot
Lake No. 9 - Hickman, KY to KY-TN State Line Levee 0/0+00 to 16/37+00	Hickman KY - Obion River System	Memphis	Mississippi River	Mississippi, New Madrid, Pemiscot
Lake No. 9 - KY-TN State Line to Mile 21/13+00 Levee - 16/37+00 to 21/13+00	Hickman KY - Obion River System	Memphis	Mississippi River	Mississippi, New Madrid, Pemiscot
Tiptonville-Obion River Levee	Hickman KY - Obion River System	Memphis	Mississippi River	Mississippi, New Madrid, Pemiscot
Tiptonville-Obion Levee 16/10+00 to 37/31+00	Hickman KY - Obion River System	Memphis	Mississippi River	Mississippi, New Madrid, Pemiscot
Mound City to Cairo Levee - 2/26+00 to 5/7+00	Mississippi and Ohio Rivers Levee System at Cairo & Vicinity	Memphis	Mississippi River	Mississippi
Mound City to Cairo Levee 5/7+00 to 8/4+00	Mississippi and Ohio Rivers Levee System at Cairo & Vicinity	Memphis	Mississippi River	Mississippi
Cairo Levee and Floodwall 8/4+00 to 14/17+00	Mississippi and Ohio Rivers Levee System at Cairo & Vicinity	Memphis	Mississippi River	Mississippi
Cairo to Cache River Diversion Channel 14/17+00 to 20/11+72	Mississippi and Ohio Rivers Levee System at Cairo & Vicinity	Memphis	Mississippi River	Mississippi
Cairo to Cache River Diversion Channel 20/11+72 to 21/13+00	Mississippi and Ohio Rivers Levee System at Cairo & Vicinity	Memphis	Mississippi River	Mississippi
Mound City to Cairo Levee - 0/11+00 to 2/26+00	Mississippi and Ohio Rivers Levee System at Cairo & Vicinity	Memphis	Mississippi River	Mississippi
Ditch 81 - Right Bank	St. Francis East to Big Lake West System	Memphis	St. Francis River	Butler, Dunklin, New Madrid, Pemiscot
St. Francis River Levee, Left Bank 0/5+00 to 15/11+00	St. Francis East to Big Lake West System	Memphis	St. Francis River	Butler, Dunklin, New Madrid, Pemiscot
St. Francis River Levee, Left Bank 15/11+66 to 31/42+25	St. Francis East to Big Lake West System	Memphis	St. Francis River	Butler, Dunklin, New Madrid, Pemiscot
St. Francis River Levee, Left Bank 26/50+00 to 43/43+00	St. Francis East to Big Lake West System	Memphis	St. Francis River	Butler, Dunklin, New Madrid, Pemiscot
SF River LB and RHC Little River RB in AR	St. Francis East to Big Lake West System	Memphis	St. Francis River	Butler, Dunklin, New Madrid, Pemiscot

Source: USACE NLD

National Flood Insurance Program (NFIP)

The National Flood Insurance Program (NFIP) defines a levee system in Title 44, Chapter 1, Section 59.1 of the Code of Federal Regulations (https://www.fema.gov/pdf/floodplain/nfip_sg_appendix_e.pdf as a flood risk reduction system that consists of a levee, or levees and associated structures like closure and drainage devices that are constructed and operated with sound engineering practices to protect a

specified area. It is a manmade structure, generally earthen that is designed and constructed with sound engineering practices to contain, control or divert the flow of water to provide temporary protection from flooding.

FEMA states on its Levee Resource Library website that it does not build, own or certify levees. The USACE is responsible for the building and maintaining levee's in its inventory and for inspection of its inventory. There may be states, communities and private levee owners that have responsibility for maintaining and operating levees according to specific guidelines. The State of Missouri does not currently have a Levee Safety Program and does not currently own or operate any levees.

FEMA's role, and thus SEMA's role as the Cooperating Technical Partner (CTP) for the State is to "*identify, analyze, and map the flood hazards associated with levees, and depict accreditation on Flood Insurance Rate Maps (FIRMs) for those levee systems for which the appropriate certification documentation has been submitted. Specifically, a levee system that is designed to reduce the hazard from the 1%-annual-chance flood may be accredited by FEMA, and areas immediately behind them mapped as a moderate-hazard zone. In order for a levee system to be accredited, a community must provide data demonstrating that the levee system is in compliance with the requirements outlined in Section 65.10 of the National Flood Insurance Program regulations. Once FEMA determines compliance with Section 65.10 has been demonstrated, the levee system can be shown as accredited on the effective FIRM panels. However, just because a levee system has been accredited on the map, does not mean that people or the property behind the levee are protected – the risk of flooding may have only been reduced, not removed. Levees can fail or be overtopped by more extreme events and the flooding that follows can be catastrophic. That is why FEMA strongly recommends that residents and business owners living near all levees carry flood insurance.*"

For levees depicted on a FIRM showing protection for the base flood elevation, FEMA categorizes levees into one of 2 categories: 1) Accredited and 2) Non-Accredited. Accredited levees are ones in which the levee owner has provided data to FEMA demonstrating that the levee system in in compliance with CFR 65.10. If a community is the process of a mapping update and the levee accreditation process is underway, a special note can be placed on the FIRMs called a Provisionally Accredited Levee or PAL note which is a temporary designation denoting that the levee owners are undergoing the accreditation process and are expecting to reach accreditation within 2 years. If accreditation has not been reached during that timeframe, a mapping project to remove the note and depict the risk without the levee is initiated.

When a levee is accredited, the flood hazard behind the levee is typically mapped as a low hazard area, and not part of the regulatory floodplain. However, according to FEMA (Living with Levees | FEMA.gov), when levees fail, or are overtopped, the results can be catastrophic. In fact, the flood damage can be greater than if the levee had not been built. Since these areas are not within the regulatory boundary of the SFHA, adoption of applicable development standards will protect lives and property.

In July 2013, FEMA Released its Levee Analysis and Mapping Procedure (LAMP) for Non-Accredited Levees New Approach which outlines the approach to use for analyzing and mapping areas of risk on the landward side of non-accredited levee systems. Previously, if a levee accreditation was not attained, an analysis called "without levee analysis" removed the levee from the prediction modeling completely and modeled as if it were not there at all and those results were shown on the mapping. A more refined approach was introduced with the LAMP process which specified a four-prong approach to modeling to make the final determination of the risk for these areas. These four components include:

1. Conducting the without levee scenario now more aptly named Natural Valley Procedure which results in a new Zone D designation,
2. Conducting an interior drainage analysis inside the protected area (landward of the levee) which assumes the levee stays in place,
3. Conducting an analysis of the flooding source assuming the levee stays in place (wet side of the levee) and
4. Merging the three resultant identified risk areas (SFHAs).

The merged results are then mapped for each levee reach. A reach is defined individually per levee system and is a continuous length of a system to which a single analysis may be applied and a mapping designation may be given. Reaches may be mapped as one of five designations depending on the analysis results: Sound Reach, Freeboard Deficient, Overtopping, Structural-Based Inundation or Natural Valley.

- **Sound Reach** is a single section of levee of any length which operates as it was designed and built to do providing protection from a base flood event. This differs from an accredited levee in that it is a section of the system working properly where the whole system may not function properly.
- **Freeboard Deficient** in which the base flood is contained by the levee but it cannot meet the freeboard standard (distance between normal water level and the top of the structure).
- **Overtopping** is applied when the base flood is above the crest of the levee but the reach is not anticipated to fail structurally.
- **Structural-Based Inundation** (also known as Breach Analysis) is for reaches with known structural integrity issues that may provide some protection by impeding some flooding conveyance but not all. It does not predict the exact location that a breach may occur or the likelihood of a breach simply a scenario that could occur for that reach.
- **Natural Valley** is modeling as if the levee reach were not present or a return to the natural ground surface before the levee was built.

Levees in Missouri Recognized through the RiskMAP Program on FEMA Digital Flood Insurance Rate Maps (DFIRMs) as Providing Protection from the 1% Annual Chance Flood:

Many levees shown on effective FIRMs were originally mapped in the 1970s and 1980s. FEMA has made a concerted effort to update these FIRMs through the RiskMAP Program. Prior to 1986, levees were shown on FIRMs as providing protection from the base flood (accredited) when they were designed and constructed in accordance with sound engineering practices. Since 1986, levees have been accredited on FIRMs only when they meet the requirements of 44 CFR 65.10 “Mapping Areas Protected by Levee Systems,” including certification by a registered professional engineer or a Federal agency with responsibility for levee design.

Levees that do not meet the requirements of 44 CFR 65.10 cannot be accredited on a FIRM. Furthermore, areas behind the levee and at risk to base flood inundation are mapped as high-risk areas subject to FEMA’s minimum floodplain management regulations and mandatory flood insurance purchase requirement.

As DFIRMs are developed, levees fall under one of the four following mapping categories:

1) Accredited Levee - With the exception of areas of residual flooding (interior drainage), if the data and documentation specified in 44 CFR 65.10 is readily available and provided to FEMA, the area behind the levee will be mapped as a moderate-risk area. There is no mandatory flood insurance purchase requirement in a moderate-risk area, but flood insurance is strongly recommended.

2) Provisionally Accredited Levee (PAL) - If data and documentation is not readily available, and no known deficiency precludes meeting requirements of 44 CFR 65.10, FEMA can allow the party seeking recognition up to two years to compile and submit full documentation to show compliance with 44 CFR 65.10. During this two-year period of provisional accreditation, the area behind the levee will be mapped as moderate-risk with no mandatory flood insurance purchase requirement.

3) De-Accredited Levees – If the information established under 44 CFR 65.10 is not readily available and provided to FEMA, and the levee is not eligible for the PAL designation, the levee will be de-accredited by FEMA. The area behind the levee will be mapped as a high-risk area subject to mandatory flood insurance purchase requirement.

4) Never Accredited Levees - levees that have never been shown on a FIRM as meeting the criteria of 44CFR65.10.

Of the 114 Missouri counties, and the City of St. Louis, 47 have levees (shown in red outline in **Figure 3.35**); of the 47 counties, 17 have levees showing protection on current FEMA FIRMs.

Figure 3.35. Missouri Counties Impacted by Levees

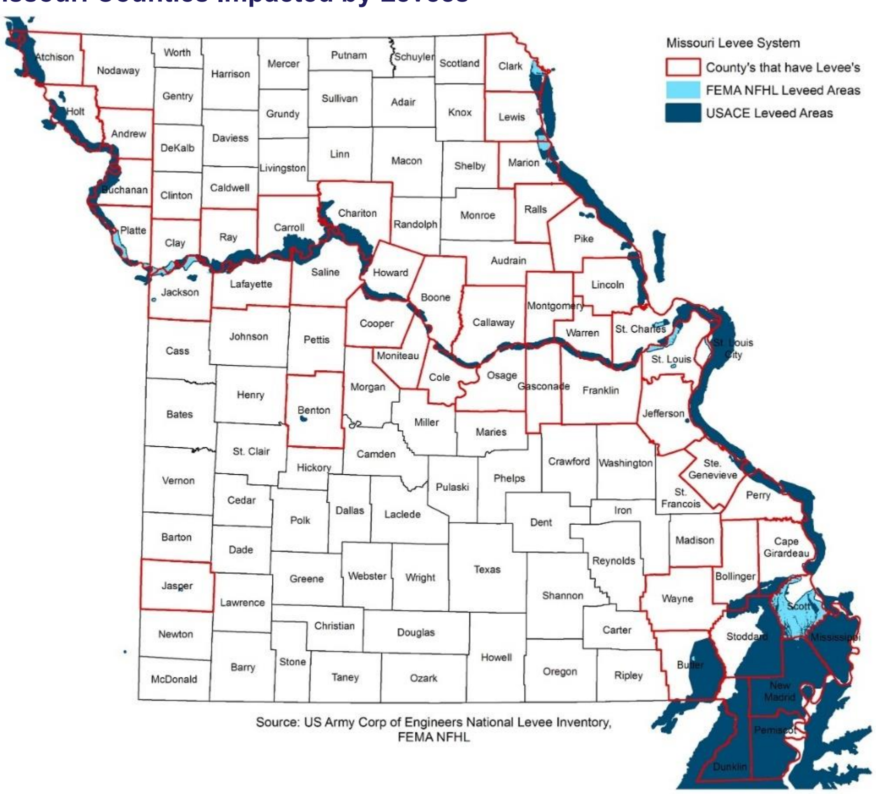


Table 3.30 provides the accreditation status of levees in these 17 counties plus the City of St. Louis as of October 2022. Since Levee Systems are made up of many Levee Reach names, these levee system reaches can be found by exporting the NLD dataset on the Hazard Mitigation Viewer website for a particular county or area from the USACE website.

Table 3.30. Levee Accreditation Status in DFIRM Counties in Missouri

County Name	Primary Community	Levee Owner	USACE Program Levee	Levee Status	Mapping Updates Underway
Andrew	Amazonia	Amazonia Levee District	Yes	De-accredited	No
Buchanan	Buchanan County Unincorporated Areas	Halls Levee District	Yes	PAL	Yes
Buchanan	Buchanan County Unincorporated Areas	Halls Levee District	Yes	PAL	Yes
Buchanan	St. Joseph & Buchanan County Unincorporated Areas	South St. Joseph Drainage District	Yes	PAL	Yes
Butler	Poplar Bluff	Butler County Drainage District No. 12	Yes	PAL	Yes
Butler	Butler County Unincorporated Areas	Central Clay Drainage District	Yes	LAMP	Yes
Butler	Butler County Unincorporated Areas	North Inter-River Drainage District	Yes	LAMP	Yes
Butler	Butler County Unincorporated Areas	Reorganized Butler County Drainage District No. 7	Yes	LAMP	Yes
Butler	Butler County Unincorporated Areas	Ring Levee Drainage District	Yes	LAMP	Yes
Cape Girardeau	City of Cape Girardeau	City of Cape Girardeau	Yes	PAL	Yes
Clark	Alexandria	Des Moines & Mississippi Levee District #1	Yes	PAL	No
Clay	Kansas City, MO	Birmingham Drainage District	Yes	PAL	No
Clay	Kansas City, MO; North Kansas City	City of Kansas City, MO	Yes	Accredited	No
Clay	North Kansas City	North Kansas City Levee District	Yes	PAL	No
Franklin	New Haven	City of New Haven	Yes	Accredited	No
Franklin	Franklin County Unincorporated Areas	Berger Levee District	Yes	PAL eligible	Yes
Franklin	Franklin County Unincorporated Areas	Labadie Bottom Levee District	Yes	PAL eligible	Yes
Franklin	Franklin County Unincorporated Areas	St. Albans Partners Levee District	Yes	PAL eligible	Yes
Franklin	Franklin County Unincorporated Areas	St. Johns Bottom Levee District	Yes	PAL eligible	Yes
Jackson	Kansas City MO	City of Kansas City MO	Yes	PAL	No
Jackson	Jackson County Unincorporated Areas	Atherton Levee District	Yes	PAL	No
Jackson	Jackson County Unincorporated Areas	Atherton-Blue Mills Levee District	Yes	PAL	No
Jackson	Kansas City MO	GSA	Yes	Accredited	No
Jackson	Levasy	Northeast Industrial District (East Bottom)	Yes	Not PAL Eligible	No
Lewis	Canton	City of Canton	Yes	PAL	No
Marion	Hannibal	City of Hannibal	Yes	Accredited	No

County Name	Primary Community	Levee Owner	USACE Program Levee	Levee Status	Mapping Updates Underway
Marion	Marion County Unincorporated Areas	South River Drainage District	Yes	PAL	No
Marion	Marion County Unincorporated Areas	Fabius River Drainage District	Yes	Accredited	No
Montgomery County	Montgomery County Unincorporated Areas	Tri-County Levee District	Yes	PAL eligible	Yes
Platte	Platte County Unincorporated Areas	Waldron Levee District	Yes	PAL	No
Platte	Platte County Unincorporated Areas	Farley-Beverly Levee District	Yes	PAL	No
Platte	Riverside	Riverside-Quindaro Bend Levee District	Yes	PAL	No
Platte	Riverside	Riverside-Quindaro Bend Levee District	Yes	PAL	No
Scott	Scott County Unincorporated Areas	Little River Drainage District	Yes	Accredited	No
St. Charles	City of St. Peters	City of St. Peters	Yes	Accredited	No
St. Charles	Unincorporated Areas	St Charles County	Yes	De-accredited	No
St. Louis	Chesterfield; St. Louis County Unincorporated Areas	Monarch-Chesterfield Levee District	Yes	Accredited	Yes
St. Louis	Maryland Heights; Bridgeton; Unincorporated Areas	Earth City Levee District	Yes	Accredited	Yes
St. Louis	Bridgeton	Missouri Bottoms Levee District	Yes	Not PAL Eligible	Yes
St. Louis	Maryland Heights	Riverport Levee District	Yes	Accredited	Yes
St. Louis	Maryland Heights; Chesterfield	Howard Bend Levee District	Yes	Accredited	Yes
St. Louis	Valley Park	City of Valley Park	Yes	Accredited	Yes
St. Louis City	City of St. Louis	City of St. Louis	Yes	Accreditation Underway	Yes
Ste. Genevieve	St. Genevieve City	St. Genevieve County Levee District No. 3	Yes	De-accredited	Yes
Warren	Warren County Unincorporated Areas	Tri-County Levee District	Yes	Accredited	Yes

Source: Federal Emergency Management Agency, as of August 2017.

Other known levees:

There are also other levees throughout the State that are intended to mitigate low-level flooding and/or protect agricultural land that are not in the USACE Levee Safety Program nor recognized on FEMA FIRMs. These levees may provide a false sense of security to residents. Information about these levees is very limited. As mapping updates are being developed, these "berms" are identified with the new LiDAR topography, as available, and are being addressed in the new engineering models.

There are non-DFIRM counties which have only paper FIRMS. These counties currently have mapping projects underway through a temporary FEMA funding allocation, Paper Inventory Reduction (PIR). The PIR counties with levees currently shown as providing protection are undergoing review by the SEMA CTP and FEMA RVII for PAL eligibility and are presented in **Table 3.31**.

Table 3.31. PIR Counties and Levee Status in Missouri

County Name	Primary Community	Levee Owner	Levee Status	Mapping Updates Underway
Atchison	Atchison County Unincorporated Areas	District	PAL eligible	Yes
Dunklin	Dunklin County Unincorporated Areas	St. Francis River District #4	PAL eligible	Yes
Holt	Holt County Unincorporated Areas	Cannon Levee District	PAL eligible	Yes
New Madrid	New Madrid County Unincorporated Areas	St. John's Levee District	PAL eligible	Yes
Mississippi	Mississippi County Unincorporated Areas	Levee District No. 3	PAL eligible	Yes
Pemiscot	Pemiscot County Unincorporated Areas	St. Francis Levee District	PAL eligible	Yes
Stoddard	Stoddard County Unincorporated Areas	Little River Drainage District	PAL eligible	Yes

Source: FEMA, Map Service Center, https://msc.fema.gov/portal

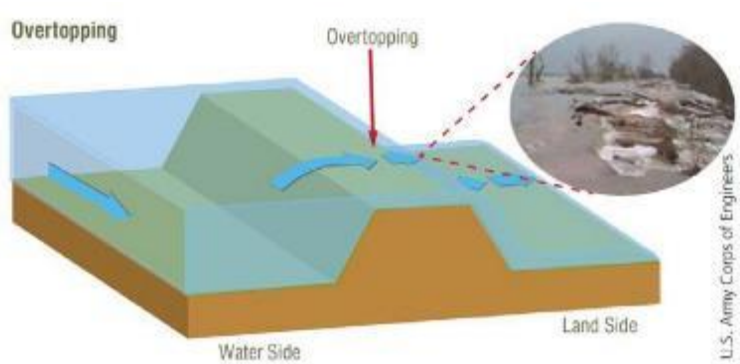
Extent

Levee failure can mean either *breaching* or *overtopping* of a levee. A levee breach is when part of the levee structure breaks away leaving an opening for water to rush through. Similar to dam failures, levee failures during flooding events damage assets with the velocity of the water caused by sudden release resulting in a flood surge or flood wave downstream. If the levee is overtopped as a result of flood waters in excess of the levee design, impacts are similar to flood impacts plus water may become trapped behind the levee in unbreeched areas, unable to drain quickly.

Overtopping: When a Flood is Too Big

Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee (see **Figure 3.36**).

Figure 3.36. Overtopping: When a Flood Is Too Big

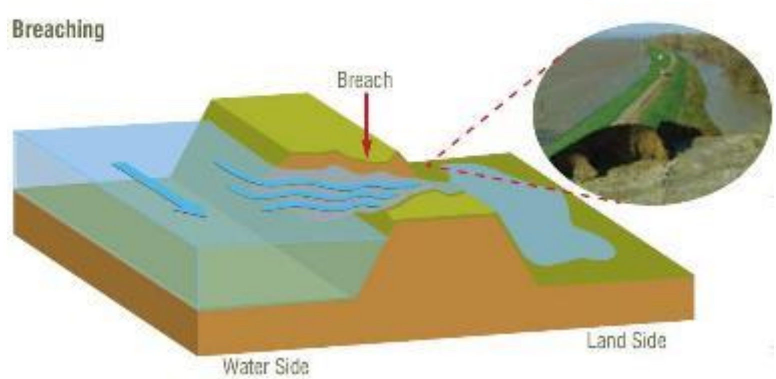


Breaching: When a Levee Gives Way

A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass (see **Figure 3.37**). A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning.

Earthen levees can be damaged in several ways. For instance, strong river currents and waves can erode the surface. Debris and ice carried by floodwaters—and even large objects such as boats or barges—can collide with and gouge the levee. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

Figure 3.37. Breaching: When a Levee Gives Way

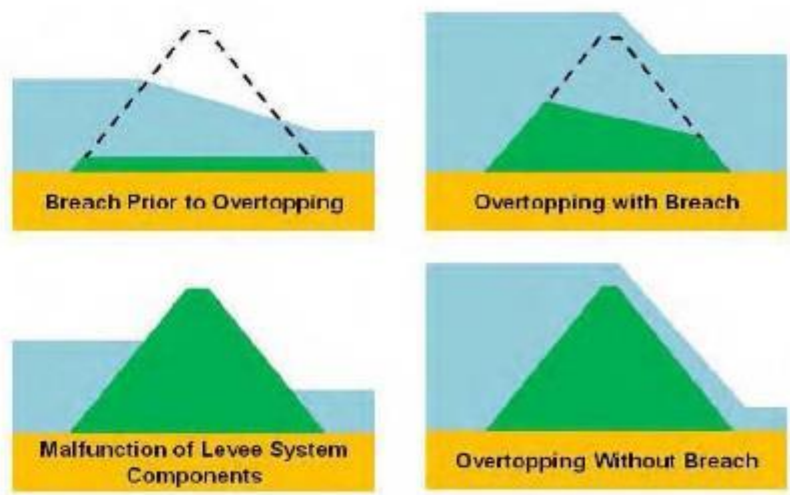


Levees are usually engineered to withstand a flood with a computed risk of occurrence. Many levees in Missouri were largely constructed to protect agricultural land and are not built to design standards established to protect people and property. Their presence can, in some cases, generate a false sense of security. If a larger flood occurs, then that structure will likely be overtopped. If during the overtopping the levee fails or is washed out, the water behind it can be released as a flash flood. Failed levees can create floods that are catastrophic to life and property in part because of the tremendous energy of the released water.

The 2013 USACE report "Hazard Mitigation Actions in Relation to State Hazard Mitigation Plans – Kansas and Missouri" presents a more refined classification scheme of levee inundation risk. In this report, a total of four scenarios are defined as posing inundation risk to the area landward of a levee system. Furthermore, the term "levee failure" was qualified as "non-desired performance." The four inundation scenarios, as shown on **Figure 3.38** are:

- Overtopping without breach
- Breach due to overtopping
- Breach before overtopping
- Non-performance of a component (such as a gate) that lead to flooding of the protected area.

Figure 3.38. Inundation Scenarios



According to the NLD, levees in the State of Missouri that are accredited against the 0.2 % and 1% annual chance flood provide protection for close to 2,200 square miles of land. The multitude of privately-constructed and maintained levees provide protection for an even greater expanse of agricultural land. Should major flood events similar to the 1993 flood strike, the severity of damage to human lives and properties from all levee failures is expected to be high. While the US Army Corps of Engineers have done major levee reconstruction for levees that are in the PL84-99 program following the 1993 flood, proper inspection, diligent maintenance, and timely repair are key to controlling the severity of levee failure damage in the event of another catastrophic flood.

Flood severity categories defined by the National Weather Service would also apply to levee failure severity categories to describe the corresponding levee reaches. The first three of these flood categories—minor, moderate, and major flooding—are bounded by an upper and lower flood stage, with flood stage defined as an established gage height for a given location at which a rise in water surface level begins to create a hazard to lives, property, or commerce.

The severity of flooding at a given stage is not necessarily the same at all locations along a levee reach due to varying channel and bank characteristics. Therefore, the upper and lower stages for a given flood category are usually associated with water levels corresponding to the most significant flood impacts somewhere in the reach.

The flood severity categories are defined as:

- Minor Flooding - minimal or no property damage, but possibly some public threat (e.g., inundation of roads)
- Moderate Flooding - some inundation of structures and roads near stream, evacuations of people and/or transfer of property to higher elevations
- Major Flooding - extensive inundation of structures and roads, significant evacuations of people and/or transfer of property to higher elevations
- Record Flooding - flooding which equals or exceeds the highest stage or discharge observed at a given site during the period of record. The highest stage on record is not necessarily above the

other three flood categories – it may be within any of them or even less than the lowest, particularly if the period of record is short (e.g., a few years)

The NWS has also defined response levels for alerting the public as to the danger of floods, as described in **Table 3.32**.

Table 3.32. National Weather Service Flood Response Levels/Activities

Alert Level	Definition
Flood Watch	A Flood Watch is issued when conditions are favorable for a specific hazardous weather event to occur. A Flood Watch is issued when conditions are favorable for flooding. It does not mean flooding will occur, but it is possible.
Flood Advisory	An Flood Advisory is issued when a specific weather event that is forecast to occur may become a nuisance. A Flood Advisory is issued when flooding is not expected to be bad enough to issue a warning. However, it may cause significant inconvenience, and if caution is not exercised, it could lead to situations that may threaten life and/or property.
Flood Warning	A Flood Warning is issued when the hazardous weather event is imminent or already happening. A Flood Warning is issued when flooding is imminent or occurring.
Flash Flood Warning	A Flash Flood Warning is issued when a flash flood is imminent or occurring. If you are in a flood prone area move immediately to high ground. A flash flood is a sudden violent flood that can take from minutes to hours to develop. It is even possible to experience a flash flood in areas not immediately receiving rain.

Source: National Weather Service

Previous Occurrences

Table 3.33 below, provides a history of levee damage for the lower Missouri River for selected levee districts from 1942 through 1993 as noted in the Preliminary Report of the Scientific Assessment and Strategy Team (1994). Some of the text that follows this table is duplicated in the Flooding Section but is repeated here in the event that only this section is pulled out by the end user.

Table 3.33. History of Levee Damage in Missouri, 1942-1993

Levee District (Area) Name	Damage Years
Mittler et al	'45, '46, '52, '53 '58, '66, '73, '82, '86, '93
Darst Bottoms	'44, '50, '58 '60, '61, '73, '86 '93
Labadie Bottoms	'42, '47, '51, '58, 66, '73, '86, '93
Pinckney-Peers	'42, 44, '48, '51, '73, '86, '93
Berger Bottoms	'42, '44, '48, '51, '57, '61, '73, '86, '93
Overton Bottoms	'42, '47, '48, '51, '57, '65, '73, '82, '86, '93
Lisbon Bottoms	'43, '44, '48, '52, '59, '60, '67. '69, '73, '79, '82, '86, '93
Cambridge	'82, '83, '84, '85, '93
Rhoades Island	'61, '73, '74, '82, '83, '84, '86, '93
Miami-DeWitt	'43, '47, '51, '67, '93

Source: Preliminary Report of the Scientific Assessment and Strategy Team, 1994

Flood of 1993

In 1993, the Midwest Flood brought issues related to levees to the forefront. The flood approached or exceeded the 100-year threshold on most major rivers and resulted in overtopping or failure of large numbers of levees, most of them agricultural levees that provided various levels of damage/risk reduction. As a result of this flooding, 840 of Missouri's estimated 1,456 levees were damaged (http://www.sej.org/publications/tipsheet/levee-threats-gaining-attention).

Although only a few of the levee systems that were credited as providing 100-year protection were overtopped or failed, several levee systems protecting major urban areas, including parts of the City of St. Louis, were threatened. Had the flood been larger, these levee systems could also have been overtopped or failed. The single most costly levee failure during the Midwest Flood was the Monarch- Chesterfield Levee at Chesterfield, Missouri. This levee was an agricultural levee that had been upgraded during the early 1980s and was credited by FEMA as providing protection from the 100-year flood. Once the levee was credited, industrial and commercial development occurred. On July 30, an area of some 4,700 acres occupied by office and industrial parks, a large general aviation airport owned by St. Louis County government and a five-mile stretch of Interstate 64 disappeared under 10 feet of water. When floodwaters threatened the levee, most businesses bought flood insurance. When the levee failed, more than $13 million in claims were paid. This translated to 5 percent of the total claims for the entire Midwest Flood. This levee has since been rebuilt and upgraded to provide 500-year flood protection. Because the levee break was in the upstream portion of the valley contained by the Monarch Levee, the floodwaters were very slow to drain out of that basin even as the level of the river dropped. Flood damage was estimated at more than $320 million in 2006 dollars.

Table 3.42 provides the number of failed or overtopped federal and non-federal levees in each USACE District during the 1993 flood event throughout the Midwest. Please note, these levee failure statistics are for the entire Midwest region impacted by the 1993 floods, not just the State of Missouri.

Table 3.34. Number of Failed or Overtopped Federal and Non-Federal Levees by USACE District—1993 Midwest Floods

USACE District	Federal	Non-Federal
St. Paul	1 of 32	2 of 92
Rock Island	12 of 73	19 of 185
St. Louis	12 of 42	39 of 47
Kansas City	6 of 48	810 of 810
Omaha	9 of 31	173 of 210
Totals	40 of 226	1043 of 1345

Source: http://www.nwrfc.noaa.gov/floods/papers/oh_2/great.htm

In response to the effects of the flood of 1993, the White House established the Scientific Assessment and Strategy Team (SAST) to provide scientific advice and assistance to policymakers and officials responsible for flood recovery and river basin management in the Upper Mississippi River Basin. According to the SAST, approximately 5 to 7 percent of the floodplain (13,000 to 18,000 acres) was substantially damaged as a result of the levee breaches during the 1993 flood within the reach from

Glasgow, Missouri to St. Louis, Missouri (about 225 river miles). Eyewitness accounts indicate that the majority of levee breaches were caused by overtopping, subsequent incision by gullies, and rapid flood-flow erosion. However, levee failures may have also been caused by underflow and piping beneath the levees, and by interflow piping within the levee structure itself.

2007 Flooding

According to a CBS news, at least 20 levees were overtopped as floodwaters made their way down Missouri streams and rivers. Nine levee breaks inundated the town of Big Lake, Missouri in Holt County. The broken levees included five on the Missouri River and four smaller levees along the Tarkio River and the Tarkio Creek (none of them operated by USACE. Levee breaks or overtopping were also reported in the following counties: Ray, Carroll, Clay, Chariton, Lafayette, Jackson, Saline and Platte. (Source: https://www.cbsnews.com/news/failing-levees-spur-major-missouri-floods/)

2008 Flooding

March— SEMA's situation report noted levee failures occurred on the Black River near Poplar Bluff, in Butler County, and in Stoddard County.

June—Several cities were wholly or partially flooded by levee failures or overtopping, including Clarksville, Winfield, Foley, and St. Charles. According to a news report, the Winfield case was especially illustrative of the fragility of some levees in the protection system, as the flood waters broke through a 3-inch tunnel dug by a muskrat and poured water out under pressure like a fire house. Many volunteers and National Guard troops were able to keep most other levees intact.

2011 Flooding

April— On April 26, 2011, the same levee that failed in the 2008 flooding near Poplar Bluff, Butler County, failed again in at least four locations along a two-mile stretch along the Black River. The threat of levee failure at another location prompted the evacuation of 1,000 people. This particular levee failed a federal inspection in 2008, receiving an "unacceptable" rating from the USACE. (Source: http://edition.cnn.com/2011/US/04/26/missouri.levee.failure/)

May – On Tuesday May 3, 2011 flooding occurred in Mississippi County when the USACE created a breach in the Birds Point-New Madrid floodway to relieve flooding in Cairo, IL by detonation of explosive along a reach of the levee. The explosion could be heard 20 miles away. Although the USACE said that flowage easements for the farmland affected by the breach allowed this action, it was an extremely controversial event that ended with a class action lawsuit being filed by many of the farmers flooded. The USACE contented that the floodway plan had not been needed since 1937 when the river had reached 59.5 feet at Cairo. It was predicted to crest at 63 feet by the National Weather Service. Breaching was predicted to drop the crest by 3-4 feet to relieve what USACE officials called "unprecedented pressure" on the system. Losses to Missouri residents totaled close to $1 billion dollars most of which was covered by crop insurance as if it were a natural disaster. (Source: http://www.stltoday.com/news/local/metro/missouri-farmland-swamped-after-levee-breach-to-help-cairo-ill/article_3c73c9f8-74ff-11e0-a74d-0019bb30f31a.html)

June— On June 13, 2011, two levees broke along the Missouri River in northwest Missouri. The first breach described by a local official and the USASCE as a "full breach" nearly 50 feet wide

occurred in Atchison County. The second breach occurred in Holt County near the Atchison/Holt County lines. (Source: http://www.cnn.com/2011/US/06/13/missouri.levee.breach/index.html).

June – On June 19, 2011 a levee in Atchison County protecting Big Lake breached near Corning, Missouri with the river breaking the historic crest record for the area at 44.6 feet. The flooding was caused by record high snowfall in the Rocky Mountains coupled with near-record spring rainfall in Montana. (Source: https://web.archive.org/web/20110621210128/http://www.kansascity.com/2011/06/19/2961113/overtopped-levees-prompt-evacuations.html) Flooding and overtopping of levees occurred along the Missouri River corridor from Council Bluff Iowa to Jefferson City Missouri throughout the month of June.

2013 Flooding

June — On June 3, 2013, residents of West Alton in St. Charles County experienced a levee overtopping on the Mississippi River near U. S. 67 and Lincoln Shields Access Rd. The breach was 100-150 foot section of the levee. The following day the Consolidated North County Levee on the Missouri River side breached. Approximately 500 residents were warned to evacuate. The Mississippi River hit about 40 feet and the Missouri River hit 34 feet. (Source: http://news.stlpublicradio.org/post/flooding-forces-evacuation-west-alton-communities-fight-rising-waters-across-region#stream/0)

2015 Flooding

December — On December 29, 2015, once again the residents of West Alton underwent evacuations as the levees were overtopped. The Mississippi river crested at 17 feet above flood stage, making it the second highest recorded crest behind only the 42.72 crest on August 1, 1993. (Source: http://fox2now.com/2015/12/29/west-alton-residents-evacuating-because-of-mississippi-flood-waters/)

2017 Flooding

May — On May 3, 2017 heavy rains in Randolph County and southern Missouri breached the Black River levee in Pocahontas Arkansas just across the Stateline after 10-15 inches of rain fell in a one week period. New water level records were set in the Midwest during this week of storms, 12 of them in Missouri. (Source: https://www.washingtonpost.com/news/capital-weather-gang/wp/2017/05/03/the-aerial-views-of-historic-missouri-and-arkansas-flooding-are-unreal/?utm_term=.8c11bd870aa1)

2019 Flooding

The 2019 flood was comparable to the 1993 flood in magnitude and severity. The flooding event was the result of heavy spring rains on frozen soil combined with rapid snowmelt and already heavy flows in the Missouri River mainstem. Levees in Nebraska, Iowa, Kansas, and Missouri were overtopped, breached, and eroded by the high-water events. As a result, severe flooding of the Missouri River and tributaries inundated 1.2 million acres, damaged infrastructure including farms, railroads, Interstate highways and caused the closure of approximately 470 roads.

There were 47 confirmed breaches at the following Levee Units: L-611-614 (South of Council Bluffs, Iowa), L-601 (South of Glenwood, Iowa), L-594 (near Fremont County, Iowa), L-575

(Fremont County, Iowa), **L-550 (Atchison County, Missouri), L-536 (Atchison and Holt Counties, Missouri)**, R-613 (Sarpy County, Nebraska), R-562 (Nemaha County, Nebraska), Western Sarpy (Ashland, Nebraska), Clear Creek (Ashland, Nebraska), Union Levee (Valley, Nebraska), and R-573 (Otoe County, Nebraska).

Two of the largest levee breaches occurred within Missouri, within Levee Unit L-550, an approximately 32-mi long levee embankment in Atchison County, managed by the Omaha District of the U.S. Army Corps of Engineers. The levee system protects small farming communities and 40,000-acres of primarily agricultural land. The two inlet breaches, Breach A and Breach B, measured 1,200-ft and 600-ft wide, respectively. Volumetric flowrate in Breach A was measured at 15,000-ft3/sec in July 2019, nearly one-third of the mean flow of the main Missouri River channel on a typical July day.

Missouri River Levee Unit L-536, in northwest Missouri in Atchison and Holt Counties, was breached in five locations and significantly damaged. **Figure 3.37** presents an aerial view of Levee L-536 after the 2019 runoff event.

Figure 3.39. Aerial View of Levee L-536, March 19, 2019

Source: USACE, Omaha District

Probability of Future Hazard Events

Given the numerous levee systems constructed along the main stems and tributaries of Missouri River and Colorado River, the State of Missouri is susceptible to catastrophic levee failure and/or overtopping. Not counting the great floods of 1993 and 2019, for the 80-year period from 1942 to 2022 for which levee failure statistics are available, over 100 levee failures/overtoppings were recorded. The USACE through its Levee Safety Program Annual Inspection programs help to minimize this threat. The probability of future events is 100%.

Changing Future Conditions Considerations

The impact of changing future conditions on levee failure will most likely be related to changes in precipitation and flood likelihood. Climate change projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on levees and increasing likelihood of levee failure. Furthermore, aging levee infrastructure and a lack of regular maintenance (including checking for seepage and removing trees, roots and other vegetation that can weaken a levee) coupled with more extreme weather events may increase risk of future levee failure.

State Vulnerability Overview

Levees have been constructed across the State of Missouri by public entities and private entities with varying levels of protection, inspection oversight and maintenance. The National Levee Safety Program Act of 2007 directed the development of a national levee safety program, in addition to the inventory and inspection of levees. As previously mentioned, two concurrent nation-wide levee inventory development efforts led by USACE and FEMA have captured the majority of levees in the State of Missouri, with the NLD focusing on the Corps' active PL84-99 program levees and the MLI focusing on levees that provide protection from 1 percent annual or higher base flood level. In fall of 2012, USACE and FEMA conducted a pilot project to integrate the NLD and MLI levees for FEMA Region VII into a single dataset, which covers the entire State of Missouri. This database continues to be further refined resulting in Missouri having a comprehensive levee GIS inventory that is spatially accurate and that reflects the best available information about levees from both federal agencies in the NLD. This data was used for high-level levee failure vulnerability analysis. **Table 3.30** is a summary of levee systems in the State of Missouri known to provide protection from 100-year or higher base flood on the FEMA FIRMs.

As part of the Risk MAP program, FEMA requires levee owners seeking recognition of 1-percent or greater flood protection on the FIRM to provide proof that levees do indeed meet the levee requirements of 44 CFR 65.10. This levee accreditation process ensures that properties shown as protected by a levee are indeed provided the level of protection as indicated on the FIRM.) When a levee is accredited, the flood hazard behind the levee is typically mapped as a low hazard area, and not part of the regulatory floodplain. However, according to FEMA (Living with Levees | FEMA.gov), when levees fail, or are overtopped, the results can be catastrophic. In fact, the flood damage can be greater than if the levee had not been built. Since these areas are not within the regulatory boundary of the SFHA, adoption of applicable development standards and flood resistant practices will protect lives and property.

To determine the population and buildings vulnerable to damage if these levee segments were to fail, the "Area Protected by Levees" feature class from the FEMA National Flood Hazard Layer (NFHL) and the USACE leveed areas from the NLD (depicted in **Figure 3.40**) were compared against the MSDIS structure point file to determine the count of structures at risk. The value of structures at risk was calculated based on determining the average value of each building type for each county from Hazus and then applying that value to the buildings counts from the MSDIS structure comparison. Population at risk was determined based on the average household size per county applied to the number of residential structures in levee protected areas. **Figure 3.40 and Figure 3.41** provide the population and building exposure by county.

Figure 3.40. Population Exposure: Missouri Levees in USACE National Levee Inventory Providing 100-year or Greater Flood Protection

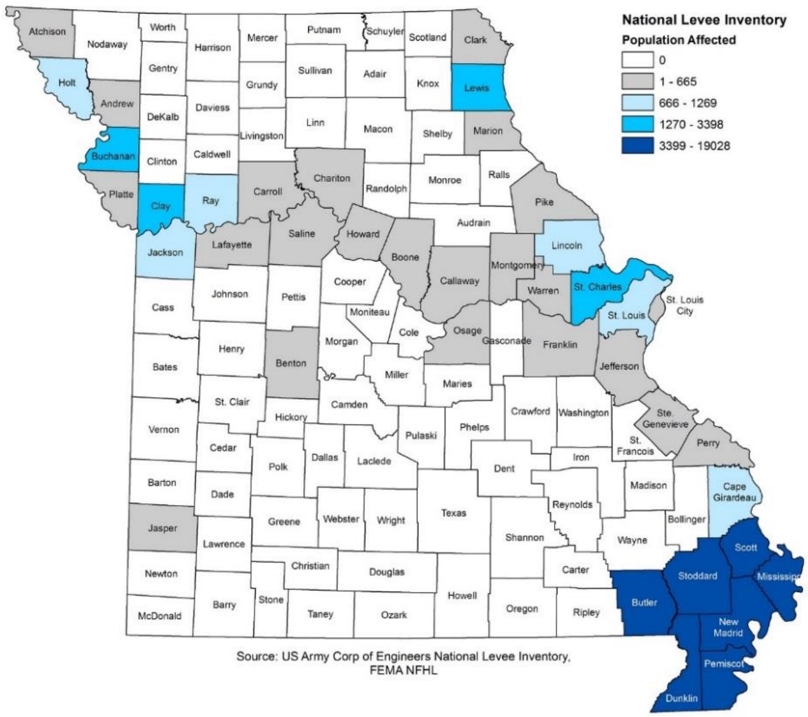
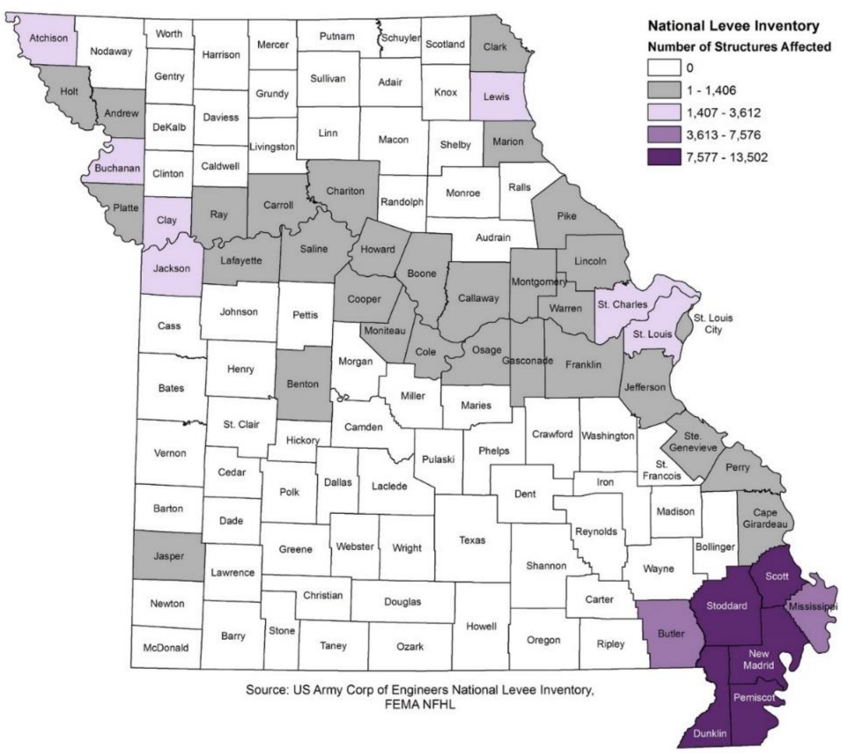


Figure 3.41. Residential Building Exposure: Missouri Levees in USACE National Levee Inventory Providing 1 percent annual chance or greater Flood Protection



State Estimates of Potential Losses

Utilizing an assumed depth-damage percentage of 50-percent, the building loss estimate for failure of levee segments designed to provide 1-percent-annual-chance flood protection is computed to be $36,253,116,594. A detailed breakdown by county is shown in **Table 3.35.** This data, including the MSDIS points, is available for export by county in the Missouri Hazard Mitigation Viewer at http://bit.ly/MoHazardMitigationPlanViewer2018.

Table 3.35. Building Loss from Levee Failure by County

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Andrew	**99**	**$29,196,819**	**72**
Agriculture	65	$17,136,938	
Commercial	3	$2,061,931	
Government	3	$2,664,382	
Residential	28	$7,333,568	72
Atchison	**1,619**	**$922,967,727**	**274**
Agriculture	1,424	$846,478,477	
Commercial	16	$12,257,417	
Industrial	42	$27,349,214	
Residential	137	$36,882,619	274
Benton	**156**	**$63,931,669**	**240**
Commercial	56	$44,722,433	
Residential	100	$19,209,236	240
Boone	**85**	**$30,135,088**	**79**
Agriculture	51	$18,578,495	
Commercial	1	$1,084,287	
Residential	33	$10,472,307	79
Buchanan	**2,230**	**$1,217,431,683**	**2,301**
Agriculture	810	$239,008,889	
Commercial	31	$36,032,316	
Education	6	$8,440,173	
Government	115	$123,668,976	
Industrial	355	$561,439,775	
Residential	913	$248,841,555	2,301
Butler	**5,308**	**$1,266,108,195**	**13,233**
Industrial	98	$103,210,462	
Residential	5,210	$1,162,897,733	13,233
Callaway	**141**	**$68,925,762**	**28**
Agriculture	63	$14,832,750	
Commercial	27	$20,603,541	
Government	12	$9,411,821	
Industrial	28	$21,257,984	
Residential	11	$2,819,667	28
Cape Girardeau	**1,286**	**$470,061,967**	1,133
Agriculture	711	$215,944,978	
Commercial	93	$93,398,050	
Government	3	$2,779,843	
Industrial	33	$30,727,868	

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Residential	446	$127,211,228	1,133
Carroll	**863**	**$646,943,505**	**225**
Agriculture	719	$564,911,882	
Commercial	8	$6,405,329	
Government	22	$20,659,297	
Industrial	23	$32,865,460	
Residential	91	$22,101,538	225
Chariton	**610**	**$650,792,239**	**267**
Agriculture	489	$610,194,040	
Commercial	21	$15,778,980	
Education	1	$2,820,941	
Residential	99	$21,998,278	267
Clark	**404**	**$287,190,225**	**244**
Agriculture	297	$260,925,234	
Commercial	8	$5,181,654	
Government	2	$1,037,990	
Residential	97	$20,045,346	244
Clay	**2,149**	**$1,570,782,729**	**3,014**
Agriculture	132	$37,737,606	
Commercial	513	$658,893,213	
Education	7	$16,418,083	
Government	17	$23,175,096	
Industrial	334	$452,618,464	
Residential	1,146	$381,940,268	3,014
Cole	**20**	**$5,522,702**	
Agriculture	20	$5,522,702	
Cooper	**4**	**$1,091,039**	
Agriculture	4	$1,091,039	
Dunklin	**9,950**	**$2,633,856,370**	17,981
Agriculture	2,179	$980,473,044	
Commercial	127	$99,506,881	
Education	26	$43,293,926	
Government	25	$13,594,340	
Industrial	6	$3,544,817	
Residential	7,587	$1,493,443,363	17,981
Franklin	**77**	**$38,352,314**	10
Agriculture	36	$139,501	
Commercial	28	$15,672,801	
Industrial	9	$21,483,144	
Residential	4	$1,056,869	10
Gasconade	**5**	**$2,562,787**	
Agriculture	2	$551,964	
Commercial	3	$2,010,822	
Holt	**1,134**	**$322,910,550**	877
Agriculture	719	$234,959,238	
Government	3	$1,666,834	
Industrial	2	$1,314,289	
Residential	410	$84,970,189	877
Howard	**134**	**$37,368,061**	**43**

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Agriculture	108	$28,425,284	
Commercial	9	$4,623,045	
Industrial	1	$522,321	
Residential	16	$3,797,412	43
Jackson	**1,956**	**$2,225,527,365**	**832**
Agriculture	200	$70,626,912	
Commercial	165	$222,908,482	
Education	4	$10,806,426	
Government	58	$100,829,337	
Industrial	1,181	$1,708,363,169	
Residential	348	$111,993,039	832
Jasper	**57**	**$54,332,108**	**18**
Agriculture	6	$2,271,787	
Commercial	1	$935,328	
Industrial	43	$49,457,118	
Residential	7	$1,667,874	18
Jefferson	**108**	**$49,275,330**	**55**
Commercial	83	$40,643,530	
Government	4	$3,543,533	
Residential	21	$5,088,267	55
Lafayette	**38**	**$4,128,656**	**10**
Agriculture	32	$1,501,201	
Commercial	1	$821,553	
Industrial	1	$724,442	
Residential	4	$1,081,460	10
Lewis	**1,960**	**$736,559,778**	**3,370**
Agriculture	272	$236,173,255	
Commercial	251	$144,003,693	
Education	4	$7,061,791	
Government	12	$5,920,209	
Industrial	34	$32,954,746	
Residential	1,387	$310,446,085	3,370
Lincoln	**656**	**$178,166,073**	**1,087**
Agriculture	242	$792,510	
Commercial	37	$71,507,527	
Government	1	$1,671,272	
Residential	376	$104,194,765	1,087
Marion	**589**	**$329,954,259**	**328**
Agriculture	164	$44,299,011	
Commercial	136	$102,214,650	
Government	3	$2,614,555	
Industrial	146	$143,367,255	
Residential	140	$37,458,788	328
Mississippi	**7,576**	**$2,113,927,676**	11,411
Agriculture	2,491	$984,265,098	
Commercial	195	$107,793,031	
Education	26	$44,621,423	
Government	29	$21,741,747	
Residential	4,835	$955,506,378	11,411

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Moniteau	**5**	**$1,315,259**	
Agriculture	5	$1,315,259	
Montgomery	**32**	**$9,700,899**	7
Agriculture	26	$7,134,815	
Commercial	3	$1,931,186	
Residential	3	$634,897	7
New Madrid	**13,502**	**$3,965,284,756**	17,035
Agriculture	5,686	$1,806,577,761	
Commercial	230	$155,096,704	
Education	65	$122,667,643	
Government	72	$42,383,133	
Industrial	169	$284,814,946	
Residential	7,280	$1,553,744,568	17,035
Osage	**80**	**$55,818,368**	**29**
Agriculture	69	$53,098,731	
Residential	11	$2,719,638	29
Pemiscot	**12,510**	**$3,463,687,921**	18,426
Agriculture	4,448	$1,367,089,176	
Commercial	352	$230,751,467	
Education	50	$103,842,810	
Government	60	$52,062,739	
Industrial	79	$109,994,067	
Residential	7,521	$1,599,947,661	18,426
Perry	**441**	**$13,188,652**	55
Agriculture	396	$2,513,385	
Commercial	23	$4,646,590	
Residential	22	$6,028,677	55
Pike	**46**	**$1,660,568**	**15**
Agriculture	40	$226,798	
Residential	6	$1,433,770	15
Platte	**929**	**$629,993,232**	**483**
Agriculture	311	$94,290,238	
Commercial	129	$136,484,209	
Government	1	$1,442,838	
Industrial	298	$326,679,299	
Residential	190	$71,096,649	483
Ray	**902**	**$350,439,616**	**1,099**
Agriculture	397	$175,815,244	
Commercial	53	$35,820,013	
Education	1	$3,524,141	
Industrial	20	$16,417,407	
Residential	431	$118,862,811	1,099
Saline	**178**	**$86,816,135**	**55**
Agriculture	157	$81,024,675	
Residential	21	$5,791,459	55
Scott	**9,996**	**$2,790,913,018**	**15,765**
Agriculture	3,484	$1,158,087,057	
Commercial	145	$116,544,900	
Education	12	$51,943,497	

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Government	8	$7,345,669	
Industrial	41	$45,889,864	
Residential	6,306	$1,411,102,032	15,765
St Charles	**2,155**	**$835,952,294**	**2,360**
Agriculture	949	$16,927,037	
Commercial	190	$199,003,370	
Education	1	$3,125,914	
Government	32	$59,999,754	
Industrial	89	$232,600,698	
Residential	894	$324,295,520	2,360
St Louis	**3,612**	**$2,802,206,934**	1,253
Agriculture	216	$45,054,578	
Commercial	2,301	$1,242,985,230	
Education	32	$61,500,082	
Government	94	$84,238,696	
Industrial	449	$1,215,645,296	
Residential	520	$152,783,051	1,253
St Louis City	**1,406**	**$2,357,675,439**	376
Commercial	108	$200,022,627	
Government	10	$332,308,817	
Industrial	1,109	$1,755,943,966	
Residential	179	$69,400,029	376
Ste Genevieve	**340**	**$133,851,436**	**662**
Agriculture	24	$61,969	
Commercial	42	$51,342,934	
Education	1	$7,116,568	
Government	2	$6,502,802	
Industrial	3	$2,584,291	
Residential	268	$66,242,873	662
Stoddard	**9,343**	**$2,772,753,183**	11,551
Agriculture	4,486	$1,351,742,989	
Commercial	144	$301,562,072	
Education	14	$29,318,535	
Government	8	$6,260,659	
Industrial	89	$72,083,767	
Residential	4,602	$1,011,785,161	11,551
Warren	**391**	**$23,856,208**	111
Agriculture	342	$928,607	
Commercial	8	$11,571,541	
Residential	41	$11,356,060	111
Grand Total	**95,082**	**$36,253,116,594**	**126,413**

Hazard Impact on Future Growth and Development

The Bootheel Area of the Missouri the counties of Butler, Dunklin, New Madrid, Mississippi, Pemiscot and Stoddard were ranked high in both population and asset vulnerability for levee failure. The counties of Buchanan, Clay, Lewis and St. Charles Counties were ranked as medium-high. Development in these counties which have large areas protected by levees, could result in the potential for increased losses as a result of the increase in exposure.

As depicted in **Table 3.8**, the top ten counties experiencing population gains (Percent) are Platte, Boone, Christian, St. Charles, Clay, Taney, Greene, Lincoln, Cape Girardeau and Webster Counties. Among these counties, levees are present in five of the top ten: Platte, Boone, St. Charles, Lincoln and Cape Girardeau. Development in these counties could also result in the potential for increased losses.

Risk Summary

Flooding is the most common hazard associated with levee failure, breach or overtopping. Levee failure, breach or overtopping can result not only in loss of life, but also considerable loss of capital investment, loss of income and property damage. Levees can provide a false sense of security by property owners and may lead to a misunderstanding of the true risk of assets in levee protected zones. While levees do provide flood protection, given enough time most will either overtop or fail leading to unsuspected damages. The Association of State Floodplain Managers (ASFPM) issued a position White Paper in 2007 calling levees the double-edged sword in which they discourage the building of new levees, development behind existing levees and increasing standards for levee construction. (Source: https://studylib.net/doc/11186230/levees--the-double-edged-sword--national-flood-policy-cha...)

Problem Statement:

The top five counties most impacted for building loss from levee failure are Pemiscot, Dunklin, New Madrid, Scott and Butler counties. Focusing mitigation efforts and dollars in these five counties would most likely prove the most successful strategy.

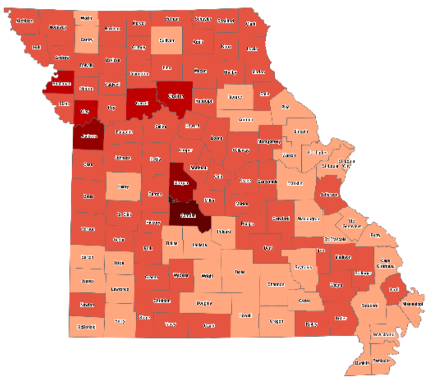
The 2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.3. Dam Failure

Description

A dam failure is characterized by an uncontrolled release of water from behind a dam. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, and terrorism can all cause a dam to fail. When a dam failure occurs, an enormous amount of water is suddenly released, destroying infrastructure and flooding the area downstream of the dam.

Vulnerability



Extent/Range of Intensity

A dam failure is characterized by an uncontrolled release of water from behind a dam. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, and terrorism can all cause a dam to fail. When a dam failure occurs, an enormous amount of water is suddenly released, destroying infrastructure and flooding the area downstream of the dam.

Probability	Severity	Location
45% 19 events in 42 years	Moderate	Statewide

State Vulnerability Overview

The downstream hazard classification system utilized by the National Inventory of Dams provides the Hazard Classification system as a means to determine overall vulnerability in the event of dam failure. According to the NID, of the 5,363 recorded dams, 1,460 (27.2%) are High Hazard, 182 (3.4%) are Significant Hazard and 3,721 (69.4%) are Low Hazard. If any of the 1,460 High Hazard dams in the state were to fail, loss of human life is likely. If any of the 182 Significant Hazard dams were to fail, loss of human life is possible. Failure of any of the 3,721 low hazard dams can result in loss of property, but loss of life is unlikely.

Changing Future Conditions Considerations

The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario.

Risk Summary/Problem Statement

The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario. Using the indicators of potential residential losses due from either State or USACE dam failure, the top five counties affected are Jackson, Greene, Clay, Boone and Cass counties.

Description/Location

A dam is generally defined as an artificial barrier, usually constructed across a stream channel, to impound water. Federal law and the Association of State Dam Safety Officials (ASDSO) define a dam as "any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation; or (2) has an impounding capacity at the maximum water storage elevation of fifty acre-feet or more." Based on this definition, there are more than 91,000 dams recorded in the United States Army Corps of Engineers (USACE) National Inventory of Dams (NID) in the United States as of October 2022. Over 94 percent of these dams are non-federal, with most being owned by state governments, municipalities, watershed districts, industries, lake associations, land developers, and private citizens. In Missouri, there are **5,363 total dams** recorded in the NID. Dam owners have primary responsibility for the safe design, operation, and maintenance of their dams. They also have responsibility for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials.

Dam construction varies widely throughout the State. The majority of dams in Missouri are earthen dams, which means they are constructed as a simple embankment of well-compacted earth. Missouri's mining industry has produced numerous tailing dams for the surface disposal of mine waste. These dams are made from mining material deposited in slurry form in an impoundment. Other types of earthen dams are reinforced with a core of concrete or asphalt. The largest dams in the State are built of reinforced concrete and are used for hydroelectric power.

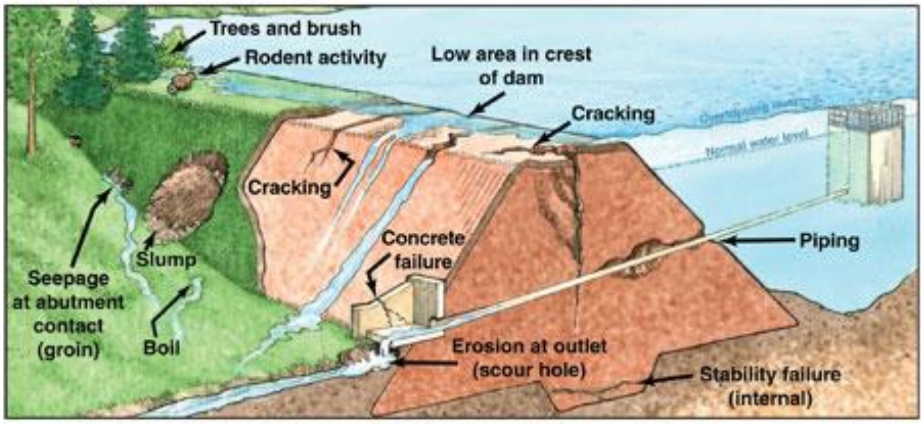
A dam failure is characterized by an uncontrolled release of water from behind a dam. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, and terrorism can all cause a dam to fail. When a dam failure occurs, an enormous amount of water is suddenly released, destroying infrastructure and flooding the area downstream of the dam.

The most common types of dam failures are as follows:

1) Overtopping – inadequate spillway design, debris blockage of spillways, or settlement of the dam crest;
2) Piping – internal erosion caused by embankment leakage, animal burrows, foundation leakage, and/or deterioration of pertinent structures appended to the dam;
3) Erosion – flow erosion, and/or inadequate slope protection;
4) Structural Failure – caused by an earthquake, slope instability, and/or faulty construction.

The four types of failures are often interrelated. For example, erosion, either on the surface or internal, may weaken the dam, which could lead to structural failure. Similarly, a structural failure could shorten the seepage path and lead to a piping failure. Observable defects that provide good evidence of potential dam failures are illustrated in **Figure 3.42.**

Figure 3.42. Possible Dam Failures



Source: United States Forest Service: https://www.fs.fed.us/eng/pubs/htmlpubs/htm12732805/page02.htm

Regulatory Framework

According to the National Inventory of Dams (NID), Missouri has **5,363 recorded dams**. The U.S. Army Corps of Engineers (USACE) is responsible for maintaining the NID and works in close collaboration with federal dam regulating agencies, including FEMA and federal and state dam regulating agencies, to obtain accurate and complete information about dams in the database. With assistance from the Missouri Department of Natural Resources, the NID inventory was also supplemented with the State Hazard Classifications for state-regulated dams. The NID includes all regulated and unregulated dams for all types of dam owners (federal, state, local, or private) that fall into one of the four following categories:

1) High Hazard: Loss of at least one human life is likely if the dam fails
2) Significant Hazard: Possible loss of human life and likely significant property or environmental destruction.
3) Equal or exceed 25 feet in height and exceed 15 acre-feet in storage
4) Equal or exceed 50-acre feet storage and exceed 6 feet in height.

Low hazard dams are those in categories 3 and 4 that do not meet the separate criteria for categories 1 and 2. Low hazard dams which do not meet the criteria specified in categories 3 or 4 are not included in the NID even if they are regulated according to state criteria. Contact the State Hazard Mitigation Officer to obtain this data.

The hazard potential classifications above do not reflect in any way the current condition of a dam; it is simply a method to provide classifications according to the type of impacts that might occur in the event of failure.

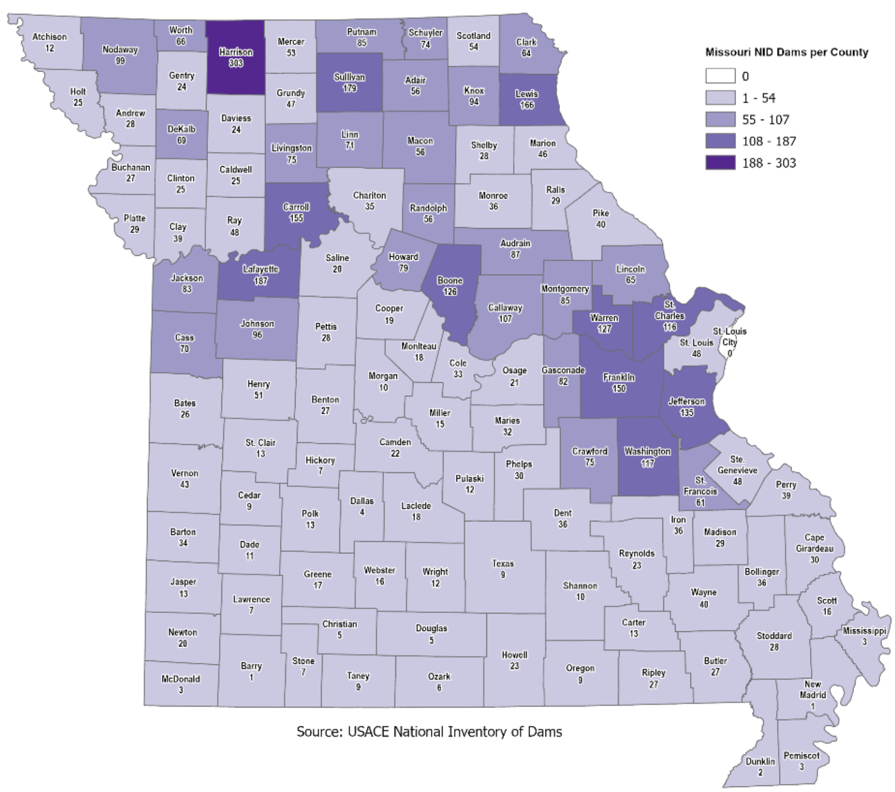
When considering the Hazard Potential Classifications of the 5,363 recorded dams in the NID:

Hazard Potential Classification	2018 State HMP	2023 State HMP	Difference
High	1,511	1,460	-51
Significant	219	182	-37
Low	3,381	3,721	340
Total	**5,111**	**5,363**	**252**

The topography of the State allows lakes to be built easily and inexpensively, contributing to the high number of dams. Despite the large number of total dams in the state, there are only **692 (about 12.9 percent) State-regulated dams**, with an additional **59 federally regulated dams**. The remaining **4,612 dams are un-regulated**.

Figure 3.43 provides the number of total recorded dams in Missouri according to the National Inventory of Dams by county. This figure is followed by **Figure 3.44**, **Figure 3.45**, and **Figure 3.46** that show the numbers of High, Significant, and Low Hazard dams respectively. **Table A.7** within **Appendix A** provides a list of all high hazard potential dams that have been identified by the state with their names, National Inventory of Dams identification numbers, locations by jurisdiction, and other relevant information.

Figure 3.43. Total Recorded Dams in Missouri by County



Source: USACE National Inventory of Dams

Figure 3.44. High Hazard Dams in Missouri by County

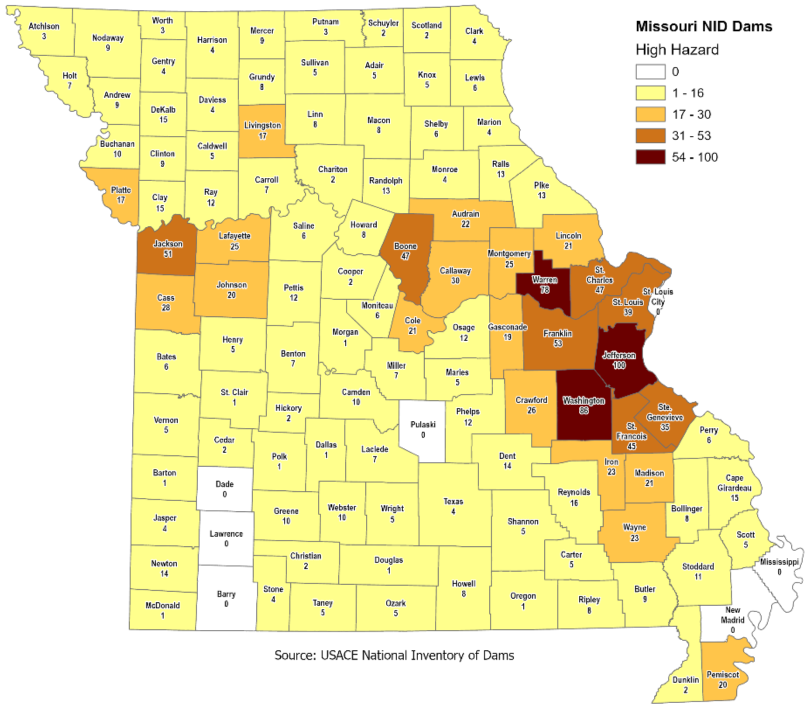


Figure 3.45. Significant Hazard Dams in Missouri by County

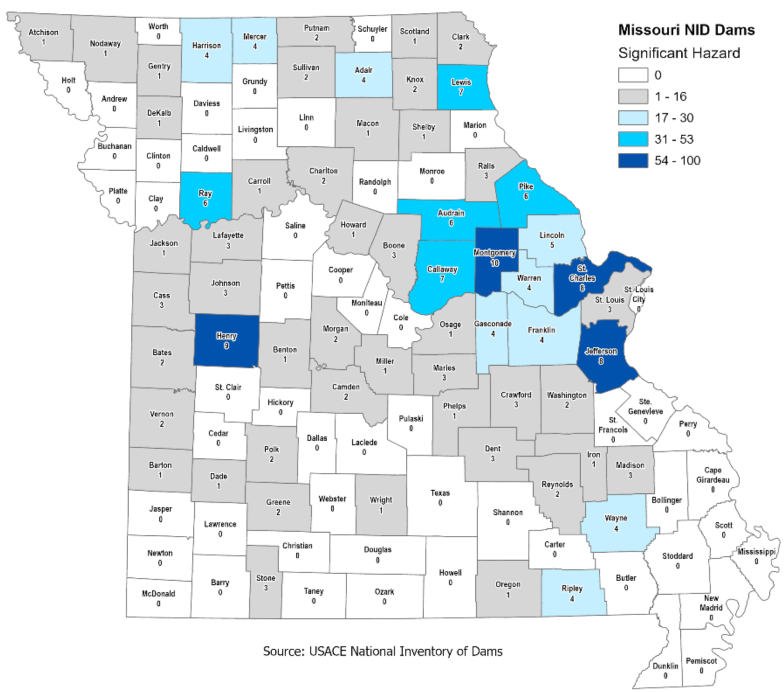
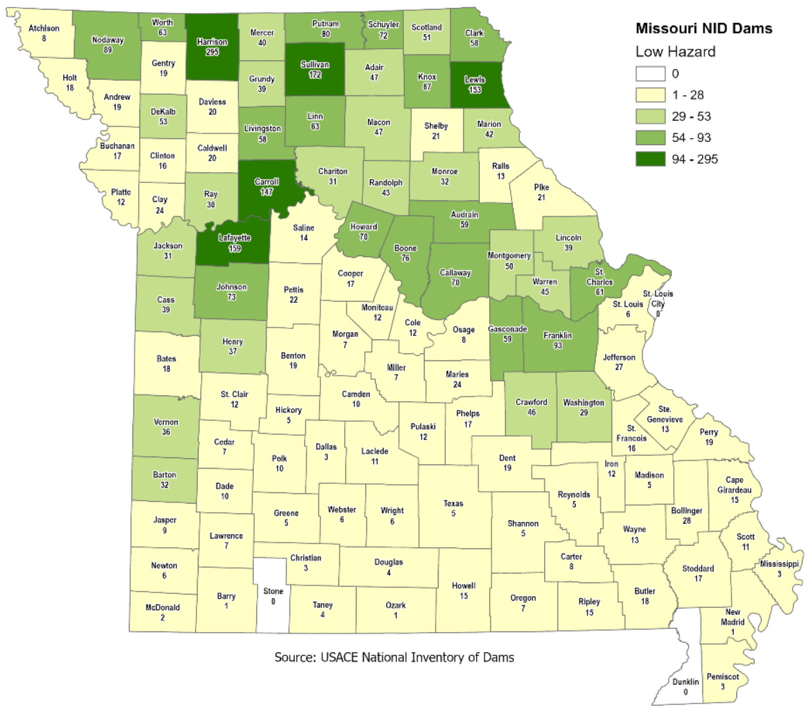


Figure 3.46. Low Hazard Dams in Missouri by County



State-Regulated Dams

Since the passage of the 1979 Missouri House Bill 603, Missouri defines any artificial or man-made barrier which does or may impound water and which impoundment is thirty-five feet or more in height as a dam that requires state regulation. The 1979 Missouri House Bill 603, as specified in Section 236.400 of the Revised Statutes of Missouri (RSMo), excluded certain dams from regulation – those less than 35 feet high, and allowed exemptions for others – those used primarily for agricultural purposes.

Dams that fall under state regulation are non-federally regulated dams that are more than 35 feet in height. Most non-federal dams are privately owned structures built either for agricultural, water supply or recreational use. Missouri also has more than 1,000 dams that were built as small watershed projects under Public Law-566 (Watershed Protection and Flood Prevention Act of 1953). These dams serve many functions, including flood control, erosion control, recreation, fish and wildlife habitat, water supply, and water quality improvement. Many of these PL-566 dams need ongoing maintenance to safely provide these functions. Another group of older dams in the State were originally built by railroad companies as holding ponds for water to be used in steam locomotives. Many of these are now used as drinking water reservoirs by nearby towns and cities. Finally, there are many mining dams that are no longer in use and have been sold to private individuals.

Within the State of Missouri, the Department of Natural Resources (MoDNR) Water Resources Center maintains a Dam and Reservoir Safety Program. The objective is to ensure that dams over 35 feet in height are safely constructed, operated, and maintained pursuant to Chapter 236 Revised Statutes of Missouri. These dams are inspected by a professional engineer once every 2-5 years, depending on the dam classification. MoDNR has three classifications for all state-regulated dams:

- Class 1: The area downstream from the dam that would be affected by inundation contains ten (10) or more permanent dwellings or any public building. Inspection of these dams must occur every two years.
- Class 2: The area downstream from the dam that would be affected by inundation contains one (1) to nine (9) permanent dwelling, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings. Inspection Of these dams must occur once every three years.
- Class 3: The area downstream from the dam that would be affected by inundation does not contain any of the structures identified for Class 1 or Class 2 dams. Inspection of these dams must occur once every five years.

The list of state regulated dams, as provided by the Missouri Department of Natural Resources GIS, includes 699 dams. This includes 7 dams not listed on the NID:

- BRUSHY CREEK TAILING #3 DAM – construction date not available
- ED BAKER #2 LAKE DAM – construction date not available
- HANKE PIT #13 DAM – completed construction 1996
- JDJ LAKE DAM – completed construction 2015
- LAKE E DAM – completed construction 2019
- MCCARTNEY DAM – completed construction 2003
- ZAHNER LAKE DAM – completed construction 2018

The NID also includes 5 dams not listed with MODNR State Dams:

- Geisz Lake Dam – MO30741, private dam in Crawford County
- Lac Tiffany Dam – MO31921, private dam in St. Francois County
- Middle Fork Water Company Dam – MO40173, public utility dam in Gentry County
- Notch Lake Dam – MO31152, private dam in St. Louis County
- West Peak Quarry Dam #2 – MO32052, private dam in Iron County

The breakdown of state-regulated dams by class is as follows: 206 Class 1, 268 Class 2, and 225 Class 3. See **Figure 3.47** through **Figure 3.50**. There is not a direct correlation between the State hazard classification and the NID hazard classifications. However, most dams that are in the State's Classes 1 and 2 are considered NID High Hazard dams.

Figure 3.47. State Regulated Dams in Missouri, Total

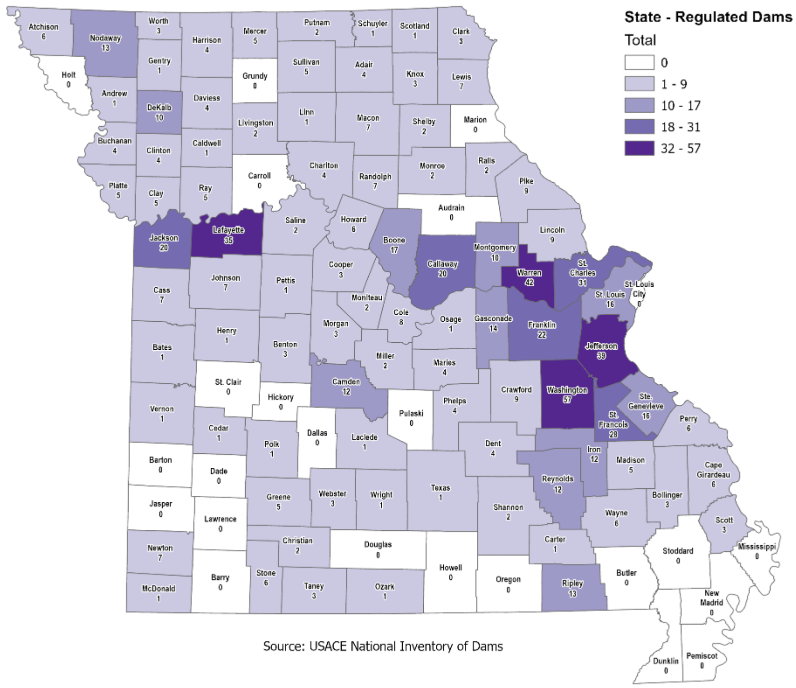


Figure 3.48. Class 1 State-Regulated Dams in Missouri

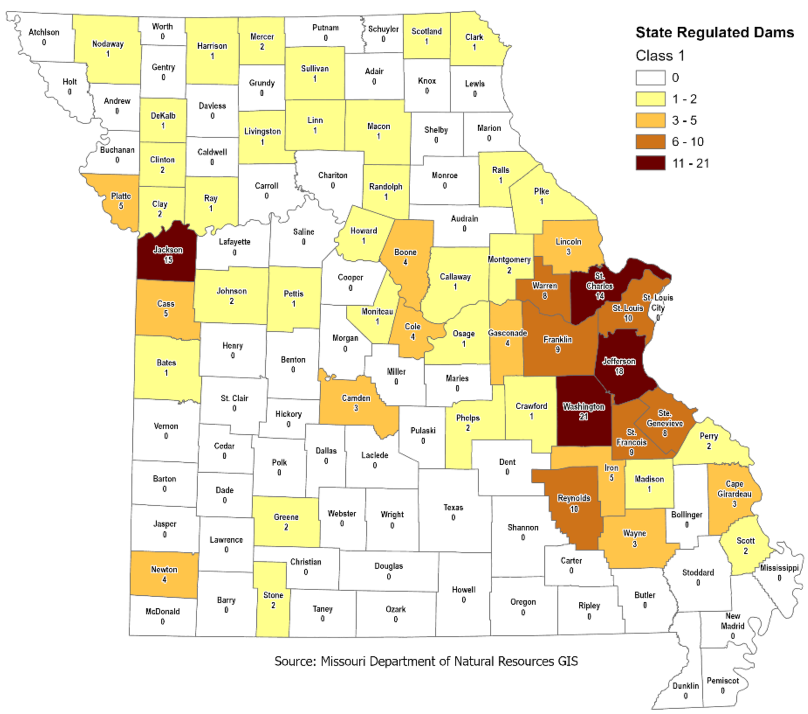


Figure 3.49. Class 2 State Regulated Dams in Missouri

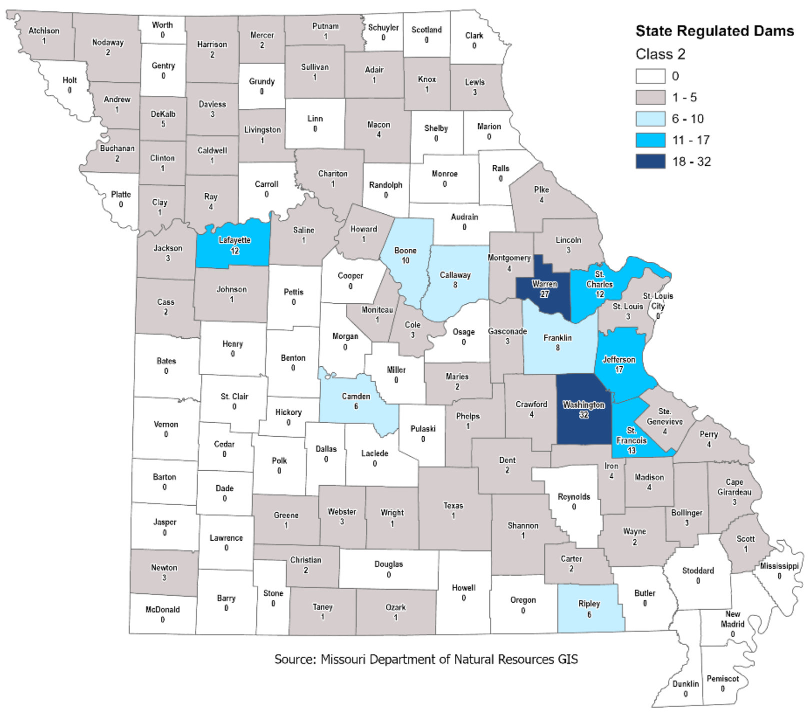
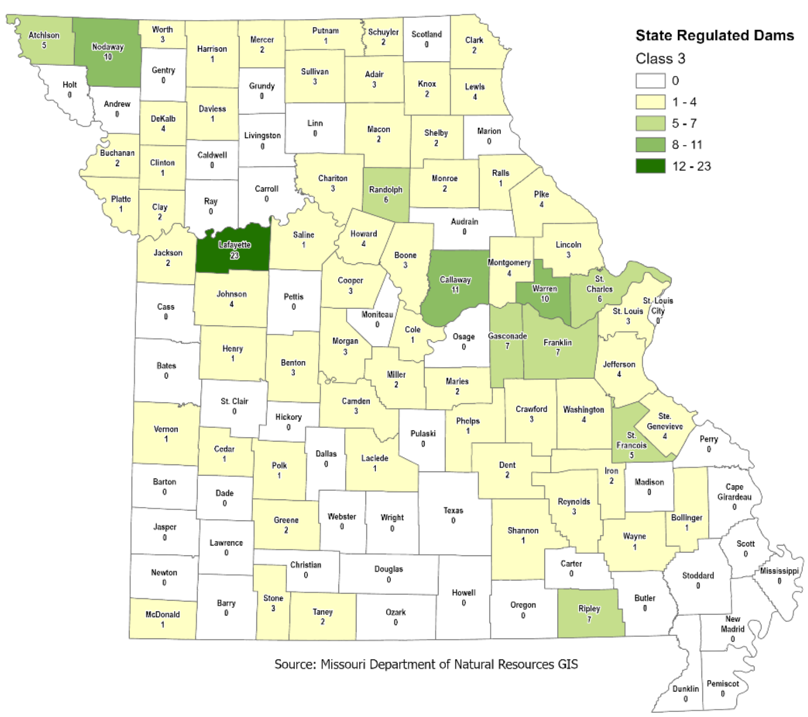


Figure 3.50. Class 3 State Regulated Dams in Missouri



Federally Regulated Dams

There are **59 federally regulated dams** in Missouri. All federally regulated dams fall outside the regulatory authority of the Missouri Dam and Reservoir Safety Program. Federal dams in Missouri are primarily regulated by two federal agencies: the U.S. Army Corps of Engineers (USACE), and the U.S. Department of Agriculture Forest Service. The Federal Energy Regulatory Commission (FERC) regulates some dams under the 1920 Federal Power Act such as the facilities at Taum Sauk and the Bagnell Power Station at the Lake of the Ozarks. These dams are permitted under their FERC permits. Other federally regulated dams are owned by the Department of Defense, the Department of Interior, electric power providers, and other entities.

Extensive care is taken in the design, construction, and operation of the USACE dams. As a result, the USACE record for dam safety is considered excellent. In Missouri, **28 dams** are maintained and operated by the USACE (see **Table 3.36**). Several relevant USACE Civil Works programs overlap with the State Risk Management Team (SRMT) in Missouri. The Silver Jackets, for example, is the USACE Civil Works program that enables participation in the state hazard mitigation team through a collaborative effort between USACE, the Federal Emergency Management Agency, and other federal, state and local agencies to create an interagency team at the state level to develop and implement solutions to state natural hazard priorities. The lead coordinator for the Silver Jackets provides regular status updates and participates on the SRMT, representing all of the USACE districts within the state at the team meetings. Each district has a Silver Jacket Coordinator that is also encouraged to attend. The status updates provide detailed information on active USACE Civil Works projects and programs, including specific project information that is useful during the FEMA RiskMAP Discovery Phases.

Table 3.36. USACE Dams in Missouri

Dam Name	NID ID	County	River	City	Owner Name
Whitaker Dam	MO20148	Henry	TR DEEP WATER CREEK	DEEPWATER	DAEN MRK
Re Mansfield Dam	MO20642	Henry	TRIB-SOUTH GRAND	CLINTON	DAEN MRK
Clinton South Quad No.1 Dam	MO20641	Henry	TRIB-SOUTH GRAND	CLINTON	DAEN MRK
Longview No 2	MO20236	Jackson	TR LUMPKINS FORK OFFSTREAM	GRANDVIEW	DAEN MRK
Longview South Dam	MO20013	Jackson	TR MOUSE CREEK	LEES SUMMIT	DAEN MRK
Blue Springs Quad No.1 Dam	MO20575	Jackson	TRIB-BLUE RIVER	BLUE SPRINGS	DAEN MRK
Mills Lake Dam (Federal)	MO20631	St. Clair	TR TO SALT CREEK	OSCEOLA	DAEN MRK
Commandeer Fishing Lake Dam	MO30224	Jackson	TR-LITTLE BLUE RIVER	INDEPENDENCE	U. S. ARMY CORPS OF ENG
Harry S. Truman Dam - Sterett Creek Dike	MO20725	Benton	OSAGE RIVER	WARSAW	USACE - Kansas City District
Harry S. Truman Dam	MO20725	Benton	OSAGE RIVER	WARSAW	USACE - Kansas City District
Stockton Dam	MO30200	Cedar	SAC RIVER	CAPLINGER MILLS	USACE - Kansas City District
Smithville Dam	MO12084	Clay	LITTLE PLATTE RIVER	SMITHVILLE	USACE - Kansas City District

Dam Name	NID ID	County	River	City	Owner Name
Pomme De Terre Dam	MO30201	Hickory	POMME DE TERRE RIVER	HERMITAGE	USACE - Kansas City District
Blue Springs Dam	MO12099	Jackson	EAST FORK LITTLE BLUE RIVER	INDEPENDANCE	USACE - Kansas City District
Longview Dam	MO82202	Jackson	LITTLE BLUE RIVER	KANSAS CITY	USACE - Kansas City District
Long Branch Dam	MO11176	Macon	EAST FORK LITTLE CHARITON	MACON	USACE - Kansas City District
Table Rock Dam	MO30202	Taney	WHITE	BRANSON	USACE - Little Rock District
Clearwater Dam	MO30203	Wayne	BLACK	LEEPER	USACE - Little Rock District
Mississippi River Lock and Dam 22	MO10305	Ralls	MISSISSIPPI RIVER	ASHBURN	USACE - Rock Island District
Mississippi River Lock and Dam 25	MO10301	Lincoln	MISSISSIPPI RIVER	WINFIELD	USACE - St. Louis District
Mississippi River Locks and Dam 27	MO10302	Madison	MISSISSIPPI RIVER	GRANITE CITY	USACE - St. Louis District
Clarence Cannon Dam - Saddle Dam	MO82201	Ralls	SALT RIVER	NEW LONDON	USACE - St. Louis District
Clarence Cannon Re-Regulation Dam	MO12086	Ralls	SALT RIVER	NEW LONDON	USACE - St. Louis District
Clarence Cannon Dam	MO82201	Ralls	SALT RIVER	NEW LONDON	USACE - St. Louis District
Wappapello Dam - Saddle Dike 3	MO30204	Wayne	ST. FRANCIS	WAPPAPELLO	USACE - St. Louis District
Wappapello Dam - Saddle Dike 1	MO30204	Wayne	ST. FRANCIS	WAPPAPELLO	USACE - St. Louis District
Wappapello Dam - Saddle Dike 2	MO30204	Wayne	ST. FRANCIS	WAPPAPELLO	USACE - St. Louis District
Wappapello Dam	MO30204	Wayne	ST. FRANCIS RIVER	WAPPAPELLO	USACE - St. Louis District

Source: National Inventory of Dams

The remaining 31 federal dams are owned by a combination of federal agencies (see **Table 3.37**).

Table 3.37. Other Federal Dams in Missouri

Dam Name	NID ID	County	River	City	Owner Name
Bloodland Quad No.3 Dam(Federal)	MO31752	Pulaski	TRIB-ROUBIDOUX CREEK	WAYNESVILLE	DOD USA
Bloodland Quad No.2 Dam(Federal)	MO31552	Pulaski	TRIB-ROUBIDOUX CREEK	WAYNESVILLE	DOD USA
Engineer Lake	MO31551	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Bloodland Lake	MO31753	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Penn S Pond	MO30976	Pulaski	Roubidoux-Hurd Hollow Tr	Waynesville	Fort Leonard Wood

Dam Name	NID ID	County	River	City	Owner Name
Red Lake	MO30977	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Big Basin	MO30978	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Veterans No. 95	MO20130	Jackson		Buckner	Lake City Aap
Silver Lake Dam	MO10307	Chariton	ELK CREEK		US FISH AND WILDLIFE SERVICE
Swan Lake Dam	MO10308	Chariton	Tough Branch		US FISH AND WILDLIFE SERVICE
Swan Lake Levee #2 Dam	MO10306	Chariton	ELK CREEK		US FISH AND WILDLIFE SERVICE
South Levee Dam	MO12421	Holt	OFFSTREAM		US FISH AND WILDLIFE SERVICE
Puxico Quad No. 1 Dam	MO40098	Wayne	TR to Mingo Creek		US FISH AND WILDLIFE SERVICE
Fox Pond Dam	MO40033	Wayne	TR to Mingo Creek		US FISH AND WILDLIFE SERVICE
Beaver Lake	MO40010	Butler	TR-TEN MILE LAKE	POPLAR BLUFF	USDA FS
Pinewoods Lake	MO31558	Carter	SOUTH FORK HOLLOW	POPLAR BLUFF	USDA FS
Huzzah 1 (Howes Mill Lake)	MO32005	Dent	HUZZAH CREEK	DILLARD	USDA FS
Scotia Pond Dam	MO31500	Dent	TRIB-MERAMEC RIVER	GLADDEN	USDA FS
Noblett	MO20101	Douglas		ROBY	USDA FS
Siloam Springs Quad No.1 Dam	MO31326	Howell	TRIB-TABOR CREEK	SILOAM SPRINGS	USDA FS
Crane Lake	MO30069	Iron	CRANE POND LAKE	DES ARC	USDA FS
Council Bluff Dam	MO31755	Iron	BIG RIVER	BLACK	USDA FS
Mccormack Dam	MO30004	Oregon	MC CORMACK HOLLOW	GREER	USDA FS
Fourche Creek Dam	MO31227	Ripley	FOURCHE CREEK	GATEWOODS	USDA FS
Ripley County Lake Dam	MO30053	Ripley	BRIAR CREEK	DONIPHAN	USDA FS
Loggers Lake	MO30002	Shannon	MILL CREEK	ROUND SPRINGS	USDA FS
Roby Lk-Embankment No. 1	MO30210	Texas	LITTLE PADDY CREEK	ROBY	USDA FS
Roby Lk-Embankment No. 2	MO30209	Texas	TR-LITTLE PADDY CREEK	ROBY	USDA FS
Sterling Hollow	MO32088	Texas	MIDDLE INDIAN CREEK		USDA FS
Timberlane Lake	MO30206	Washington	TR-COURTOIS CREEK	COURTOIS	USDA FS
Markham Springs Dam(Federal)	MO30207	Wayne	TR BLACK RIVER	WILLIAMSVILLE	USDA FS

Source: National Inventory of Dams

Unregulated Dams

4,612 dams in Missouri (more than 86%) do not meet the height requirements for state-regulation and do not fall under federal regulation. Many of these dams have gone unchecked for decades because there is no legal authority or state allocated manpower available to inspect them. Dams that do not get regular attention can erode over the years or may be damaged by floods. These dams can be considered vulnerable. If a dam fails, the owner is responsible for the damages that may be caused, regardless of whether or not the dam is regulated.

On the next several pages the **Table 3.38** provides an inventory of the numbers and types of dams in Missouri by County including the total in the NID, State-Regulated dams, Federally-Regulated dams, and Un-regulated dams.

Table 3.38. Numbers and Types of Dams in Missouri by County

County	Count of NID Dams				Count of State Regulated Dams				Count of Federally Regulated Dams				Count of Un-Regulated Dams			
	H	S	L	Total	1	2	3	Total	H	S	L	Total	H	S	L	Total
Adair	5	4	47	56		1	3	4					4	3	45	52
Andrew	9		19	28		1		1					8	0	19	27
Atchison	3	1	8	12		1	5	6					2	0	4	6
Audrain	22	6	59	87									22	6	59	87
Barry			1	1									0	0	1	1
Barton	1	1	32	34									1	1	32	34
Bates	6	2	18	26	1			1					5	2	18	25
Benton	7	1	19	27			3	3	2			2	5	1	16	22
Bollinger	8		28	36		3	1	4					5	0	28	33
Boone	47	3	76	126	4	10	3	17					33	2	74	109
Buchanan	10		17	27		2	2	4					8	0	15	23
Butler	9		18	27							1	1	9	0	17	26
Caldwell	5		20	25		1		1					4	0	20	24
Callaway	30	7	70	107	1	8	11	20					21	4	62	87
Camden	10	2	10	22	3	6	3	12					1	0	9	10
Cape Girardeau	15		15	30	3	3		6					9	0	15	24
Carroll	7	1	147	155									7	1	147	155
Carter	5		8	13		2		2			1	1	4	0	7	11
Cass	28	3	39	70	5	2		7					23	1	39	63
Cedar	2		7	9			1	1	1			1	1	0	6	7
Chariton	2	2	31	35		1	3	4			3	3	1	2	25	28
Christian	2		3	5		2		2					0	0	3	3
Clark	4	2	58	64	1		2	3					3	1	57	61
Clay	15		24	39	2	1	2	5	1			1	11	0	22	33
Clinton	9		16	25	2	1	1	4					6	0	15	21
Cole	21		12	33	4	3	1	8					14	0	11	25
Cooper	2		17	19			3	3					2	0	14	16
Crawford	26	3	46	75	1	4	3	8					20	3	43	66
Dade		1	10	11									0	1	10	11
Dallas	1		3	4									1	0	3	4
Daviess	4		20	24		3	1	4					1	0	19	20
Dekalb	15	1	53	69	1	5	4	10					9	1	49	59
Dent	14	3	19	36		2	2	4	1		1	2	11	2	17	30
Douglas	1		4	5							1	1	1	0	3	4
Dunklin	2			2									2	0	0	2
Franklin	53	4	93	150	9	8	7	24					38	2	88	128
Gasconade	19	4	59	82	4	3	7	14					12	1	55	68
Gentry	4	1	19	24									3	1	19	23
Greene	10	2	5	17	2	1	2	5					7	0	5	12

Count of NID Dams

County	H	S	L	Total
Grundy	8		39	47
Harrison	4	4	295	303
Henry	5	9	37	51
Hickory	2		5	7
Holt	7		18	25
Howard	8	1	70	79
Howell	8		15	23
Iron	23	1	12	36
Jackson	51	1	31	83
Jasper	4		9	13
Jefferson	100	8	27	135
Johnson	20	3	73	96
Knox	5	2	87	94
Laclede	7		11	18
Lafayette	25	3	159	187
Lawrence			7	7
Lewis	6	7	153	166
Lincoln	21	5	39	65
Linn	8		63	71
Livingston	17		58	75
Macon	8	1	47	56
Madison	21	3	5	29
Maries	5	3	24	32
Marion	4		42	46
Mcdonald	1		2	3
Mercer	9	4	40	53
Miller	7	1	7	15
Mississippi			3	3
Moniteau	6		12	18
Monroe	4		32	36
Montgomery	25	10	50	85
Morgan	1	2	7	10
New Madrid			1	1
Newton	14		6	20
Nodaway	9	1	89	99
Oregon	1	1	7	9
Osage	12	1	8	21
Ozark	5		1	6
Pemiscot			3	3
Perry	20		19	39
Pettis	6		22	28

Count of State Regulated Dams

County	1	2	3	Total
Grundy				
Harrison	1	2	1	4
Henry			1	1
Hickory				
Holt				
Howard	1	1	4	6
Howell				
Iron	5	4	2	11
Jackson	15	3	2	20
Jasper				
Jefferson	18	17	4	39
Johnson	2	1	4	7
Knox		1	2	3
Laclede			1	1
Lafayette		12	23	35
Lawrence				
Lewis		3	4	7
Lincoln	3	3	3	9
Linn	1			1
Livingston	1	1		2
Macon	1	4	2	7
Madison	1	4		5
Maries		2	2	4
Marion				
Mcdonald			1	1
Mercer	2	2	2	6
Miller			2	2
Mississippi				
Moniteau	1	1		2
Monroe			2	2
Montgomery	2	4	4	10
Morgan			3	3
New Madrid				
Newton	4	3		7
Nodaway	1	2	10	13
Oregon				
Osage	1			1
Ozark		1		1
Pemiscot				
Perry	2	4		6
Pettis	1			1

Count of Federally Regulated Dams

County	H	S	L	Total
Grundy				
Harrison				
Henry			3	3
Hickory	1			1
Holt			1	1
Howard				
Howell			1	1
Iron	2			2
Jackson	3		4	7
Jasper				
Jefferson				
Johnson				
Knox				
Laclede				
Lafayette				
Lawrence				
Lewis				
Lincoln		1		1
Linn				
Livingston				
Macon	1			1
Madison		1		1
Maries				
Marion				
Mcdonald				
Mercer				
Miller				
Mississippi				
Moniteau				
Monroe				
Montgomery				
Morgan				
New Madrid				
Newton				
Nodaway				
Oregon		1		1
Osage				
Ozark				
Pemiscot				
Perry				
Pettis				

Count of Un-Regulated Dams

County	H	S	L	Total
Grundy	8	0	39	47
Harrison	1	4	294	299
Henry	5	9	33	47
Hickory	1	0	5	6
Holt	7	0	17	24
Howard	6	0	67	73
Howell	8	0	14	22
Iron	11	0	11	22
Jackson	30	1	25	56
Jasper	4	0	9	13
Jefferson	65	7	24	96
Johnson	17	1	71	89
Knox	4	2	85	91
Laclede	7	0	10	17
Lafayette	13	0	139	152
Lawrence	0	0	7	7
Lewis	3	4	152	159
Lincoln	15	4	36	55
Linn	7	0	63	70
Livingston	15	0	58	73
Macon	2	0	46	48
Madison	16	2	5	23
Maries	3	1	24	28
Marion	4	0	42	46
Mcdonald	1	0	1	2
Mercer	6	4	38	48
Miller	7	1	5	13
Mississippi	0	0	3	3
Moniteau	4	0	12	16
Monroe	4	0	30	34
Montgomery	19	10	46	75
Morgan	1	0	6	7
New Madrid	0	0	1	1
Newton	7	0	6	13
Nodaway	6	1	79	86
Oregon	1	0	7	8
Osage	11	1	8	20
Ozark	4	0	1	5
Pemiscot	0	0	3	3
Perry	14	0	19	33
Pettis	5	0	22	27

	Count of NID Dams				Count of State Regulated Dams				Count of Federally Regulated Dams				Count of Un-Regulated Dams			
County	**H**	**S**	**L**	**Total**	**1**	**2**	**3**	**Total**	**H**	**S**	**L**	**Total**	**H**	**S**	**L**	**Total**
Phelps	12	1	17	30	2	1	1	4					9	0	17	26
Pike	13	6	21	40	1	4	4	9					9	5	17	31
Platte	17		12	29	5		1	6					12	0	12	24
Polk	1	2	10	13			1	1					1	2	9	12
Pulaski			12	12							7	7	0	0	5	5
Putnam	3	2	80	85		1	1	2					2	1	80	83
Ralls	13	3	13	29	1		1	2	2	2		4	10	0	13	23
Randolph	13		43	56	1		6	7					12	0	37	49
Ray	12	6	30	48	1	4		5					7	6	30	43
Reynolds	16	2	5	23	10		3	13					7	1	3	11
Ripley	8	4	15	27		6	7	13	1	1		2	1	1	10	12
Saline	6		14	20		1	1	2					5	0	13	18
Schuyler	2		72	74			2	2					2	0	71	73
Scotland	2	1	51	54	1			1					1	1	51	53
Scott	5		11	16	2	1		3					2	0	11	13
Shannon	5		5	10		1	1	2	1			1	3	0	4	7
Shelby	6	1	21	28			2	2					6	0	20	26
St. Charles	47	8	61	116	14	12	6	32					23	3	59	85
St. Clair	1		12	13							1	1	1	0	11	12
St. Francois	45		16	61	9	13	5	27					23	0	10	33
St. Louis	39	3	6	48	10	3	3	16					26	1	5	32
Ste. Genevieve	35		13	48	8	4	4	16					23	0	9	32
Stoddard	11		17	28									11	0	17	28
Stone	4	3		7	2		3	5					1	0	0	1
Sullivan	5	2	172	179	1	1	3	5					3	2	169	174
Taney	5		4	9		1	2	3	1			1	3	0	2	5
Texas	4		5	9		1		1	1		2	3	2	0	3	5
Vernon	5	2	36	43			1	1					5	1	36	42
Warren	78	4	45	127	8	27	10	45					45	2	38	85
Washington	86	2	29	117	21	32	4	57			1	1	33	0	26	59
Wayne	23	4	13	40	3	2	1	6	2	3	3	8	16	1	9	26
Webster	10		6	16		3		3					7	0	6	13
Worth	3		63	66			3	3					3	0	60	63
Wright	5	1	6	12		1		1					4	1	6	11
Grand Total	**1,460**	**182**	**3,721**	**5,363**	**206**	**268**	**225**	**699**	**20**	**9**	**30**	**59**	**974**	**115**	**3,523**	**4,612**

Source: NID, MoDNR dam data in MSDIS supplemented by direct consultation with MoDNR Dam Safety Program Officials.

Dams Outside State Boundaries that Could Impact Missouri

Dams located outside of the State's boundaries could impact Missouri as well. Of particular concern is the Tuttle Creek Dam in Riley, Pottawatomie, and Marshall Counties in northeast Kansas on the Big Blue River, nine miles upstream from the confluence of the Blue and Kansas Rivers. It is situated near the Humboldt fault line, which is associated with the Nemaha Uplift. Earthquake models show that the dam could be significantly damaged to the point that the lake could wash out the dam. Efforts have been made to shore up the dam to withstand a moderate to large earthquake.

The Gavins Point Dam located on the Missouri River in South Dakota is another dam outside of Missouri's boundaries that has the possibility of impacting the State in the case of failure. There are a number of reports that focus on past and future spring pulse releases from this structure in addition to studies on possible water storage increases within the system. The USACE's Missouri River Master Manual provides additional information. Other upstream USACE dams that have inundation areas that extend into Missouri are listed in **Table 3.39**.

Table 3.39. Out-of-State USACE Dams with Inundation Areas Extending into Missouri

Dam Name	State (Origin)
Fort Peck Dam	Montana
Fort Randall Dam	South Dakota
Garrison Dam	North Dakota
Gavins Point Dam	Nebraska
Oahe Dam	South Dakota
Tuttle Creek Dam	Kansas
Milford Dam	Kansas
Big Bend Dam	South Dakota
Rathbun Dam	Iowa
Harlan County Dam	Nebraska
Clinton Dam	Kansas
Perry Dam	Kansas
Saylorville Dam/Big Creek	Iowa
Hillsdale Dam	Kansas
Melvern Dam	Kansas
Pomona Dam	Kansas
Red Rock Dam	Iowa

Source: U.S. Army Corps of Engineers

Locations in Missouri at Risk to Dam Failure

Locations at risk to dam failure in Missouri can be defined as any areas within the dam inundation areas (also referred to as dam breach areas). The State Vulnerability Overview section provides information about the number of mapped dam inundation areas in the State.

Although efforts are being made on a continuing basis, there are still many dams in Missouri that do not have identified inundation areas. As described above, there are 4,612 dams in Missouri that are not regulated by a state or federal agency. Of those, 1,039 are high hazard dams. Although areas downstream of those dams are at risk in the event of failure, the specific locations at risk have not been identified.

Extent

The extent (strength or magnitude) of dam failure hazard is based on the dam height and reservoir volume. Both of these factors impact the height of the downstream flood wave and the extent of wave propagation. Additional details on the extent of dam failure are excerpted below from FEMA's *Federal Guidelines for Dam Safety*, April 2004.

The area affected by dam failure during a given flow condition on a river is the additional area inundated by the incremental increase in flood elevation due to failure over that which would occur normally by flooding without dam failure. The area affected by a flood wave resulting from a theoretical dam breach is a function of the height of the flood wave and the downstream distance and width of the river at a particular location. An associated and important factor is the flood wave travel time. These elements are primarily a function of the rate and extent of dam failure, but also are functions of channel and floodplain geometry and roughness and channel slope.

Previous Occurrences

Over the years, dam failures have injured or killed thousands of people and caused billions of dollars in property damage in the United States. Among the most catastrophic were the failures of the Teton dam in Idaho in 1976, which killed 14 people and caused more than $1 billion in damage, and the Kelly-Barnes Dam in Georgia in 1977, which left 39 dead and $30 million in property damage.

The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977, and the December 14, 2005 collapse of the Upper Reservoir of AmerenUE's Taum Sauk hydroelectric complex in Reynolds County. Many of Missouri's smaller dams are becoming a greater concern as they continue to age and deteriorate. Hundreds of dams are in need of rehabilitation. However, a lack of funding and questions of ownership have made it difficult to implement the necessary maintenance.

According to Stanford University's National Performance of Dams Program and additional research, there have been 98 dam failure incidents in Missouri. One failure was recorded to be in 1917. All others in this repository of data occurred between 1975 and 2016. No new events have been reported since 2016.

Table 3.40. Dam Incidents in Missouri, 1917-2016

Dam Name	Incident Date	Incident Type	Dam Failure	NID ID
Ozark Beach	5/1/1917	N/A	No	MO30088
Powersite Dam	5/1/1917	Sliding	Unknown	Unknown
Lee Lake	1/1/1938	Uknown	Unknown	Unknown
Braddock Lake Dam	1/1/1963	Inflow Flood - Hydrologic Event	Yes	Unknown
Colley Lake	1/1/1963	Inadequate Spillway Capacity	Yes	Unknown
Hannibal Dam	1/1/1969	Unknown	Unknown	MO10061
Howell County Dam	2/1/1969	Inflow Flood - Hydrologic Event	Yes	Unknown
Dresser No.4 Dam (Failed)	8/15/1975	Piping	Yes	MO30474
Dresser No.4 Dam (Failed)	8/15/1975	Piping	No	MO30474
Unnamed Dam (MOS00014)	1/1/1977	Inflow Flood - Hydrologic Event	No	MOS00014
National Lead Tailings Pond Dam	1/1/1977	Inflow Flood - Hydrologic Event	Yes	Unknown
Pinkston	1/1/1978	Piping	Yes	MOS00013
Clarence Cannon Cofferdam & Main Embankment	1/1/1981	Inflow Flood - Hydrologic Event	Yes	Unknown
Richardet Dam	12/1/1985	Seepage; Embankment Slide	Yes	MO31374
Marschke Lake Dam	4/19/1988	Not Known	Yes	MO31923
St. Joe State Park Sediment Impoundment	2/15/1990	Inflow Flood - Hydrologic Event; Inadequate Spillway Capacity	Yes	MOS00004
Blue Springs No Name Dam	5/1/1990	Inflow Flood - Hydrologic Event	Yes	Unknown
Bass Lake Dam	5/15/1990	Inflow Flood - Hydrologic Event	No	MO11224
Bullard Lake Dam	5/15/1990	Inflow Flood - Hydrologic Event	No	MO10620
Allen Dale Subdivision Dam	5/21/1990	Inflow Flood - Hydrologic Event	No	MOS00006

Dam Name	Incident Date	Incident Type	Dam Failure	NID ID
Rogue Creek Upper Dam (Incomplete)	5/25/1990	Inflow Flood - Hydrologic Event	No	MO31849
Pinnacle Lake Dam	6/7/1990	Inflow Flood - Hydrologic Event	No	MO30923
Woodridge Lake Dam	6/8/1990	Embankment Erosion	No	MO11005
Hester Lake Dam	6/27/1990	Not Known	Yes	MO12279
Brushy Creek Tailings Dam	1/9/1991	Toe Berm Erosion	No	MO30951
Hester Lake Dam	4/9/1991	Piping	Yes	MO12279
Brays Lake Dam	5/13/1991	Inflow Flood - Hydrologic Event	No	MO30098
Mcnulty Lake Dam	5/13/1991	Inflow Flood - Hydrologic Event	No	MO31915
Lake Viking Dam	10/28/1991	Not Known	No	MO10414
Lake Wappapello	1/1/1992	Not Known	Yes	Unknown
Miller Lake Dam	4/2/1992	Embankment Slide	No	MO31725
No Name (owned by Lonnie Hollaway)	5/25/1992	Embankment Slide	No	MOS00001
ISP Minerals, Inc. Plant	6/3/1992	Not Known	Yes	MO31988
ISP Minerals, Inc. Plant	6/3/1992	Tailings Pile Failure	No	MO31988
Unnamed Dam (MOS00015)	6/5/1992	Erosion	Yes	MOS00015
Harrison County Lake (aka West Fork of Big Creek C1 Dam)	1/3/1993	Inflow Flood - Hydrologic Event	Yes	MO12370
Las Brisas Lake Dam	5/24/1993	Seepage; Embankment Erosion	No	MO30541
Norman Swinney's Dam	5/26/1993	Inadequate Compaction	Yes	MOS00002
Robbins Lake Dam	5/26/1993	Embankment Slide	No	MO11260
Stevens Lake Dam	6/1/1993	Inflow Flood - Hydrologic Event	Yes	MO10107
City of Higbee Dam	6/18/1993	Seepage	No	MO10660
Bockelman Lake Dam	7/1/1993	Inflow Flood - Hydrologic Event	Yes	MO31526
Lake Marie Dam	7/8/1993	Embankment Erosion	No	MO10154
Carp and Commandeer Dams	7/14/1993	Inflow Flood - Hydrologic Event	No	MO20166
Trenton Lower Lake Dam	7/14/1993	Inflow Flood - Hydrologic Event	No	MO10366
Hidden Lake Dam	7/16/1993	Embankment Erosion	No	MO31452
Lake Viking Dam	7/22/1993	Inflow Flood - Hydrologic Event	No	MO10414
Lake Viking Dam	8/9/1993	Inflow Flood - Hydrologic Event	No	MO10414
Mozingo Creek Dam	8/10/1993	Inflow Flood - Hydrologic Event	No	MO12277
Trenton Lower Lake Dam	8/10/1993	Inflow Flood - Hydrologic Event	No	MO10366
F.E.M., Inc. Lake Dam (aka Claysville Lake Dam)	8/11/1993	Inflow Flood - Hydrologic Event	No	MO12234
Sunny Mount Dam	9/23/1993	Animal Attack	No	MO30832
Boyd Lake Dam	9/25/1993	Embankment Slide	Yes	MO31996
Freddies Lake Dam	9/26/1993	Inflow Flood - Hydrologic Event	Yes	MO32026
Lake Arrowhead Dam	10/5/1993	Inflow Flood - Hydrologic Event	No	MO10581
Lac Shayne Dam	10/7/1993	Embankment Slide	No	MO31835
Fellows Lake Dam	10/28/1993	Concrete Deterioration	No	MO20036
Holiday Acres Lake Dam	1/3/1994	Seepage; Embankment Slide	No	MO10135
Dresser #11 Tailings Pond Dam	2/17/1994	Concrete Deterioration	No	MO31422
Four Winds Way Dam	3/1/1994	Concrete Deterioration	No	MO30722
Prairie Lee Lake Dam	4/22/1994	Embankment Slide	No	MO10044
Goose Creek Dam	4/27/1994	Concrete Deterioration	No	MO31743
Bettison	5/26/1994	Embankment Slide	No	MOS00003
Seven Lakes #1	6/21/1994	Concrete Cracking	No	MO30347
Silver Creek Lake Dam	6/21/1994	Concrete Deterioration	No	MO31846
Mozingo Creek Dam	7/7/1994	Inflow Flood - Hydrologic Event	No	MO12277
Unnamed Dam	7/14/1994	Debris - Reservoir	No	MOS00007
Shatto Lake Mill Dam	7/21/1994	Inflow Flood - Hydrologic Event	No	MO20754
Seven Lakes #1	8/24/1994	Embankment Slide	No	MO30347
Unnamed Dam	8/30/1994	Seepage; Piping	No	MOS00008
Nehai Tonkayea Lake Dam	11/14/1994	Embankment Slide	No	MO10627
Lake Arrowhead Dam	11/15/1994	Embankment Slide	No	MO10581

Dam Name	Incident Date	Incident Type	Dam Failure	NID ID
NEHAI TONKAYEA LAKE DAM	2/27/1995	Inflow Flood - Hydrologic Event	No	MO10627
City of Higbee Dam	3/23/1995	Embankment Slide	No	MO10660
Lake Arrowhead Dam	5/17/1995	Inflow Flood - Hydrologic Event	No	MO30572
Sunny Shores Dam	6/21/1995	Seepage	No	MO20237
Bowling Green #1 Dam	6/26/1995	Seepage; Piping	No	MO10262
Unnamed Dam	8/24/1995	Inflow Flood - Hydrologic Event	No	MOS00009
Owl Creek Estates Dam No. 3	8/31/1995	Embankment Slide	No	MO31960
Wells Lake Dam	12/7/1995	Cracks/Tree Growth	No	MO20447
Nehai Tonkayea Lake Dam	12/10/1995	Embankment Slide	No	MO10627
Iron Mountain Lake Dam	4/22/1996	Embankment Erosion	No	MO30057
Block Lake Dam	4/28/1996	Inflow Flood - Hydrologic Event	No	MO32038
Macon Lake Dam	5/7/1996	Inflow Flood - Hydrologic Event	No	MO10153
Tamarack Dam	5/31/1996	Inflow Flood - Hydrologic Event	No	MO30452
102 Riv Trib Wtrshd Strctr Lt-36	12/4/1996	Debris - Reservoir	No	MO11258
Lake Venita Dam	2/21/1997	Seepage; Piping	Yes	MO20164
Schacktenberg Company Dam	2/26/1997	Animal Attack	No	MO20805
Carp Lake Dam	3/2/1997	Embankment Slide	No	MO30217
Unnamed Dam	3/5/1997	Inflow Flood - Hydrologic Event	No	MOS00011
Unnamed Dam (Schacktenberg Company Dam?)	8/2/1997	Seepage; Piping	No	MOS00010
Christiansen Lake Dam	5/1/1999	Embankment Erosion	Yes	MO20145
Lake Flamingo Dam	6/6/2001	Seepage/Piping	No	MO11241
T-69 Watershed Site	8/22/2001	Concrete Deterioration	No	MOS00012
Junior Lake Dam	11/14/2001	Swallow Hole	No	MO11526
Taum Sauk	12/14/2005	Suspected Instrumentation Failure	Yes	Not Reported
Moon Valley Lake Dam	3/17/2008	Unknown	Yes	Not Reported
Wappapello Lake Dam	05/02/2011	Emergency Spillway overflow	No	Not Reported
Glover Spring Lake Dam	August 2016	Overtopping/some damage	No	Not Reported

Source: Stanford University National Performance of Dams Program, https://npdp.stanford.edu/dam_incidents

The most notable dam failure in recent history was the December 14, 2005 breach in the Taum Sauk reservoir dam owned by AmerenUE of St. Louis. A 600-foot breach in the northwest side of the retention facility released 1.5 billion galls of stored water into the Johnson Shut-Ins State Park in 10 minutes' time. The waters destroyed the park and the park Superintendent's house and swept the Superintendent's family out of their house. All five family members survived. The lower reservoir was overtopped by the flow of the east fork of the Black River. As a precautionary measure, the City of Lesterville (Reynolds County) evacuated 100-150 people to higher ground. If the dam had failed during the summer months during the park's peak use, it is likely that many lives would have been lost.

Figure 3.51. 2005 Failure of AmerenUE's Taum Sauk Reservoir Dam

Source: State of Missouri Attorney General's Office

The 2011 floods in Missouri led to the Corps of Engineers having to release record levels of water through the Gavin Point Dam. This release did cause downstream flooding; however, the reservoirs upstream were at 100% capacity. The difficult choice to release so much water was supported by local officials. In Wyatt, Missouri during the same event, the Corps of Engineers breached the Bird's Point Levee in order to reduce pressure on a floodwall protecting the town. In Wayne County, Wappapello Dam overflowed to its emergency spillway into the St. Francis River, see **Figure 3.52**. The spillway functioned as designed and water over the spillway posed no risk to the dam structure. However, Highway T across the dam was destroyed, along with the fiber optics and water lines going across the dam. Although these events were not dam failures, they represent examples of intentional releases that caused downstream flooding to avoid potential failure, overtopping or pressure on upstream areas.

Figure 3.52. Wappapello Dam Overflow to Emergency Spillway

Source: AP Photo/Daily American Republic, Paul Davis)

Although not included in the Stanford University National Performance of Dams incidents, there was a dam incident in Callaway County, Missouri in August of 2016. Glover Spring Lake, a man-made lake created in 1956 east of Fulton overflowed after 8 inches of rain fell. Increased water levels split the dam and floodwaters rushed under a bridge on County Road 101 and into Crows Fork and Auxvasse Creeks. County Road 101 was closed to traffic after rainfall and the overflow washed away road sections on both sides of the bridge. Routes UU and O were also impacted. The dam did not completely fail and there were no known injuries. No homes or farms downstream were flooded. If the dam had fully collapsed, there would have been additional damages.

Probability of Future Hazard Events

For the 42-year period from 1975 to 2016 for which dam failure statistics are available, 19 dam failures and 68 incidents are recorded. According to this data, annual probability calculates to a 45 percent annual probability of a dam failure somewhere in the state and a 100 percent annual probability of dam incidents. In should be noted that historical dam failures and incidents include events from all hazard classes and all dams (whether regulated or un-regulated). Failures and incidents for regulated dams that have higher inspection frequencies should be less probable. The probability of future events is 45%.

Changing Future Conditions Considerations

Studies have been conducted to investigate the impact of climate change scenarios on dam safety. Dam failure is already tied to flooding and the increased pressure flooding places on dams. The impacts of changing future conditions on dam failure will most likely be those related to changes in precipitation and flood likelihood. Changing future conditions projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on dams and increasing likelihood of dam failure.

The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario.

State Vulnerability Overview

The downstream hazard classification system utilized by the National Inventory of Dams provides the Hazard Classification system as a means to determine overall vulnerability in the event of dam failure. According to the NID, of the 5,363 recorded dams, 1,460 (27.2%) are High Hazard, 182 (3.4%) are Significant Hazard and 3,721 (69.4%) are Low Hazard. If any of the 1,460 High Hazard dams in the state were to fail, loss of human life is likely. If any of the 182 Significant Hazard dams were to fail, loss of human life is possible. Failure of any of the 3,721 low hazard dams can result in loss of property, but loss of life is unlikely.

The dam hazard classification system is a means to classify dams according to what impacts could occur in downstream inundation areas. However, this system does not indicate the structural integrity of the dam or likelihood of failure. For regulated dams, there are two main processes in place to advance dam safety: 1) Inspection and 2) Emergency Action Planning.

Inspection of Dams

State and Federal-regulated dams are inspected regularly with the frequency of inspection based on the hazard class. Results of inspections may result in necessary corrective actions. For State-regulated dams in Missouri, Class 1 dams are inspected every two years, Class 2 dams are inspected every three years, and Class 3 dams are inspected every five years.

Table 3.41 below provides the summary of the inspection findings provided in the National Inventory of Dams for State regulated dams.

Table 3.41. Inspection Rating Summary, State-Regulated Dams

Ratings	Class 1	Class 2	Class 3	Total
Not Rated	11	4	25	40
Satisfactory	447	54	140	641
Unsatisfactory	8		3	11
Total	**466**	**58**	**168**	**692**

Source: National Inventory of Dams

A summary of the unsatisfactory ratings by county is provided in **Table 3.42.**

Table 3.42. Unsatisfactory Ratings by County, State-Regulated Dams

County	Class 1	Class 3	Total
Franklin		1	1
Lafayette	1	2	3
Ripley	3		3
St. Charles	1		1
Warren	1		1
Washington	2		2
Grand Total	**8**	**3**	**11**

Source: National Inventory of Dams

For federally regulated dams regulated by USACE, two types of dam inspections and completed. The first one is the Annual Inspection, which is performed on an annual basis to ensure the dam is being properly operated and maintained. The Periodic Inspection is the next level of inspection and is conducted by a multidisciplinary team led by a professional engineer. It includes a more detailed, comprehensive evaluation of the condition of the dam and will be conducted every five years. Components of the Periodic Inspection include evaluating annual inspection items; verifying proper operation and maintenance; evaluating operational adequacy, structural stability, and safety of the system; and comparing current design and construction criteria with those in place when the dam was built (http://www.usace.army.mil/Missions/Civil-Works/Dam-Safety-Program/Program-Activities/).

In 2005, the USACE started Screening for Portfolio Risk Analysis (SPRA). This analysis screened every one of the approximately 694 dams in the USACE inventory based on available information, to expeditiously identify and classify the highest risk dams requiring urgent and compelling action (Dam Safety Action Classification Classes I and II Dams). This screening has yielded a clear but basic understanding of where the greatest risks and priorities are located.

Completing SPRA has allowed USACE to develop a Portfolio Investment Plan for more than 300 dams within the portfolio determined to be “actionable,” or posing moderate to extremely high risks.

The Dam Safety Action Classification System (DSAC) is intended to provide consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are placed into a DSAC class based on their individual dam safety risk considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. The DSAC table presents different levels and urgencies of actions that are commensurate with the different classes of the safety status of USACE dams. These actions range from immediate recognition of an urgent and compelling situation requiring extraordinary and immediate action for unsafe dams through normal operations and dam safety activities for safe dams.

1) DSAC Class I (Very High Urgency) – Dams where progression toward failure is confirmed to be taking place under normal operations and the dam is almost certain to fail under normal operations within a time frame from immediately to within a few years without intervention; or, the combination of life or economic consequences with probability of failure is extremely high.
2) DSAC Class II (High Urgency) – Dams where failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety; or, the combination of life or economic consequences with probability of failure is very high.
3) DSAC Class III (Moderate Urgency) – Dams that have issues where the dam is significantly inadequate or the combination of life, economic, or environmental consequences with probability of failure is moderate to high.
4) DSAC Class IV (Low Urgency) – Dams are inadequate with low risk such that the combination of life, economic, or environmental consequences with a probability of failure is low and the dam may not meet all essential USACE engineering guidelines.
5) DSAC Class V (Normal) – Dams considered adequately safe, meeting all essential agency guidelines and the residual risk is considered tolerable.

Due to their sensitive nature, the DSAC Classes of USACE dams are not available for publication.

The USACE is actively engaged in a program to assess and communicate risk associated with dams and levees. Actions to reduce inundation risks associated with USACE programs have been termed interim risk reduction measures (IRRMs). IRRMs are temporary actions taken to reduce inundation risks posed by dams and/or levees while longer term solutions are planned and implemented. The IRRMS do not preclude or in any way replace long term measures needed to reduce any risk. IRRMs are a critical part of responsible, adaptive flood risk management and recognize the dynamic nature of flood risk. In establishing IRRMs, the prevention of loss of life is the highest priority. **Table 3.43** provides a summary of risk evaluations for USACE dams in Missouri.

Table 3.43. Risk Evaluations for USACE Dams

Dam Name	Owner	Risk Evaluation Concerns	Interim Risk Reduction Measures
Lock and Dam No. 20	USACE-MVR	Miter gate failure due to barge impact Instability due to scour Miter gate anchorage failure Spillway gate due to barge impact	Update EAP Scour monitoring Regular inspections Risk assessment in FY16 New miter gates
Lock and Dam No. 21	USACE-MVR	Miter gate failure due to barge impact Instability due to scour Miter gate anchorage failure Spillway gate due to barge impact	Update EAP Scour monitoring Regular inspections New miter gates

Dam Name	Owner	Risk Evaluation Concerns	Interim Risk Reduction Measures
Lock and Dam No. 22	USACE-MVR	Miter gate failure due to barge impact Miter gate anchorage failure Spillway gate due to barge impact	Update EAP Regular inspections New miter gates Designing new Tainter gates
Bear Creek Dam	City of Hannibal	Seepage along the conduit concentrated leak erosion between the embankment fill and shale backward erosion piping	Removed vegetation from abutments Routinely operate and grease gates Remove sediment and debris from the intake
Red Rock Dam	USACE-MVR	Seepage and piping through the soluble gypsum layer Concentrated leak erosion between the embankment fill and bed rock Slope stability of the embankment Concentrated leak erosion at the spillway/ embankment interface Failure of Tainter gates	Red Rock Hydropower Project under construction Red Rock foundation investigation Regular inspections Regular Tainter gate operations and maintenance Instrumentation monitoring
Blue Springs Dam	USACE-NWK	Blue Springs Dam is considered low risk within the USACE portfolio. Concerns at the dam include low confidence in the hydrologic adequacy of the dam and the need to communicate risk to recent downstream developments.	None
Clinton Dam	USACE-NWK	Clinton Dam is considered low risk within the USACE portfolio. Concerns at the dam include the need to communicate risk to the downstream community and spillway erosion during rare flood events.	None
Harlan County Dam	USACE-NWK	Harlan County Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include the bearing friction of the spillway tainter gates and potential sliding of the spillway along the foundation rock.	The tainter gates and sluiceway gates are currently under construction to replace gate bearings and structurally strengthen the tainter gates. Irrigation lines have been inspected and/or replaced. The dam surveillance plan and emergency action plan have been updated.
Hillsdale Dam	USACE-NWK	Hillsdale Dam is considered low risk within the USACE portfolio. Concerns at the dam include the elevation of the chimney drain and possible erosion on the upstream clay blanket.	None
Kanopolis Dam	USACE-NWK	Kanopolis Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include overtopping during the probably maximum flood, erosion through the buried collector system, and erosion along the construction shutdown interface.	USACE will be communicating the risk of overtopping to the population within the inundation area and updating the dam surveillance plan and emergency action plan.
Harry Truman Dam	USACE-NWK	Harry Truman Dam is considered low risk within the USACE portfolio. Concerns at the dam include the spillway potentially being undersized for extremely rare loading conditions.	None
Long Branch Dam	USACE-NWK	Long Branch Dam is considered low risk within the USACE portfolio. Concerns at the dam include the potential for spillway erosion during rare flood events and the lack of a drain within the upper portion of the embankment.	None
Longview Dam	USACE-NWK	Longview Dam is considered low risk within the USACE portfolio. Concerns at the dam include the potential for spillway erosion during rare flood events.	None

Dam Name	Owner	Risk Evaluation Concerns	Interim Risk Reduction Measures
Melvern Dam	USACE-NWK	Melvern Dam is considered low risk within the USACE portfolio. Concerns at the dam include seepage and potential piping within the left abutment.	None
Milford Dam	USACE-NWK	Milford Dam is considered low risk within the USACE portfolio. Concerns at the dam include overtopping due to wind/wave action during an extremely rare flood event, contact erosion along the closure section, seepage through the right abutment, and erosion within the spillway.	None
Perry Dam	USACE-NWK	Perry Dam is considered low risk within the USACE portfolio. Concerns at the dam include the stability of the stilling basin and seepage through the foundation.	None
Pomme de Terre Dam	USACE-NWK	Pomme de Terre Dam is considered low risk within the USACE portfolio. Concerns at the dam include erosion within the rock-fill embankment.	None
Pomona Dam	USACE-NWK	Pomona Dam is considered low risk within the USACE portfolio. Concerns at the dam include erosion within the foundation and abutments and the breakdown of the upstream riprap embankment protection.	None
Rathbun Dam	USACE-NWK	Rathbun Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include seepage through the foundation sands during high pool events and inadequacy of the stilling basin for large releases.	Thresholds have been established for piezometers in the abutments and valley. USACE has communicated the risks associated with the dam to local communities. The dam surveillance plan and emergency action plan have been updated to reflect potential problem areas.
Smithville Dam	USACE-NWK	Smithville Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include instability of the abutment during rare and unusual flood events.	USACE is completing a stability analysis on the left abutment. USACE has communicated the risks associated with the dam to local communities. New instrumentation has been installed on the dam. The dam surveillance plan and emergency action plan have been updated.
Stockton Dam	USACE-NWK	Stockton Dam is considered low risk within the USACE portfolio. Concerns at the dam include seepage and erosion into the foundation.	None
Tuttle Creek Dam	USACE-NWK	Tuttle Creek Dam is considered low risk within the USACE portfolio. Concerns at the dam include spillway erosion and seismic failure.	None
Wilson Dam	USACE-NWK	Wilson Dam is considered low risk within the USACE portfolio. Concerns at the dam include overtopping, spillway erosion, and potential for settlement during rare flood events.	None

Source: U.S. Army Corps of Engineers

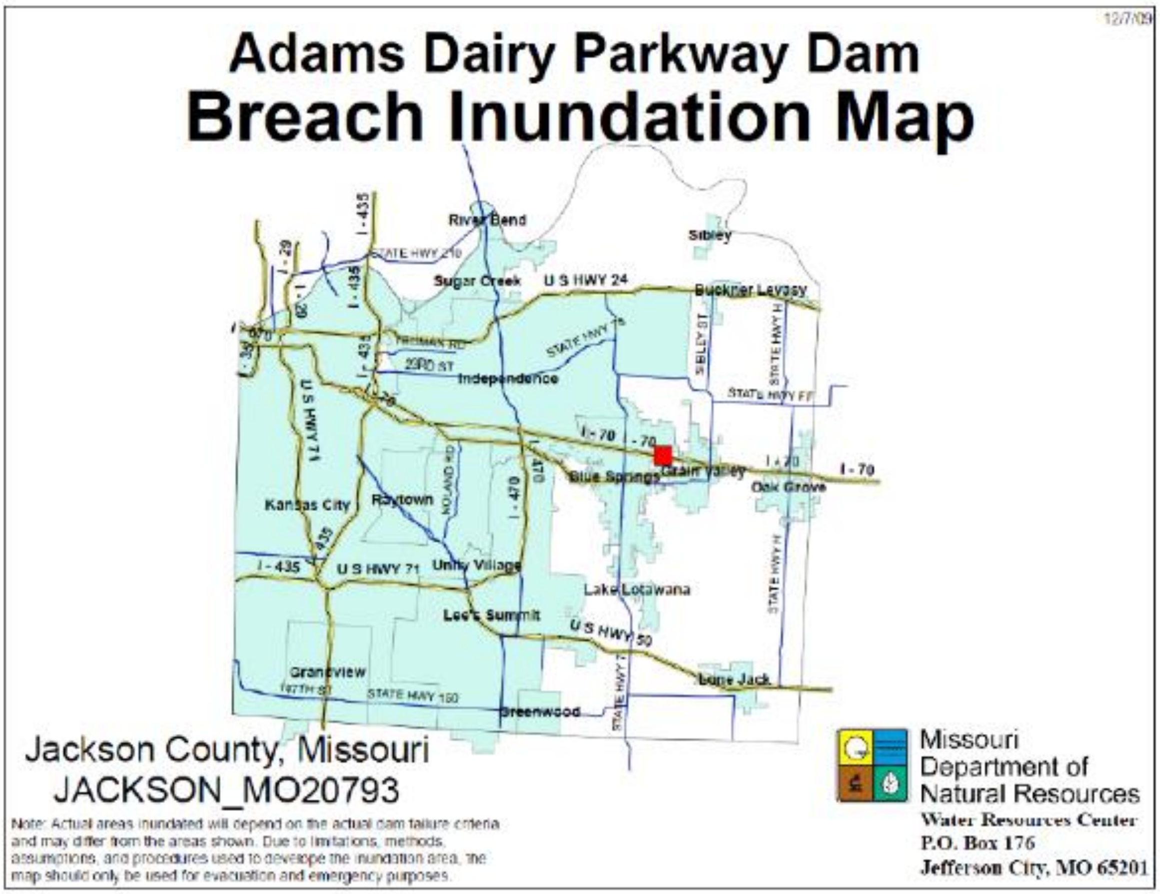
Missouri dams regulated by other federal agencies are inspected by the regulatory federal agency.

Emergency Action Planning/Inundation Mapping

An Emergency Action Plan (EAP) helps emergency managers know the structures that are at risk as well as the roads that will be flooded so that evacuation routes and emergency management efforts can be

developed accordingly. Since 2009, the Missouri Department of Natural Resources has been working with dam owners and emergency personnel to develop Emergency Action Plans. A dam inundation map is an important part of the EAP for all state-regulated high-hazard potential dams in Missouri. The EAP template that was developed by the Missouri Department of Natural Resources can be found on the Dam and Reservoir Safety Program Emergency Action Planning Website. To date, over 400 Emergency Action Plans with inundation maps have been completed by dam owners with the assistance of their county emergency management directors (EMD). **Figure 3.53** provides an example inundation map for Adams Dairy Parkway Dam in Jackson County, Missouri.

Figure 3.53. Sample Inundation Map, Adams Dairy Parkway Dam, MoDNR



Source: Missouri Department of Natural Resources

Each USACE dam also has an emergency action plan and inundation map. These EAPs are updated generally on an annual basis. Inundation maps for all USACE dams are in various stages of development. The USACE Modeling, Mapping, and Consequences (MMC) Production Center, which is part of the USACE Risk Management Center, are tasked with producing these maps.

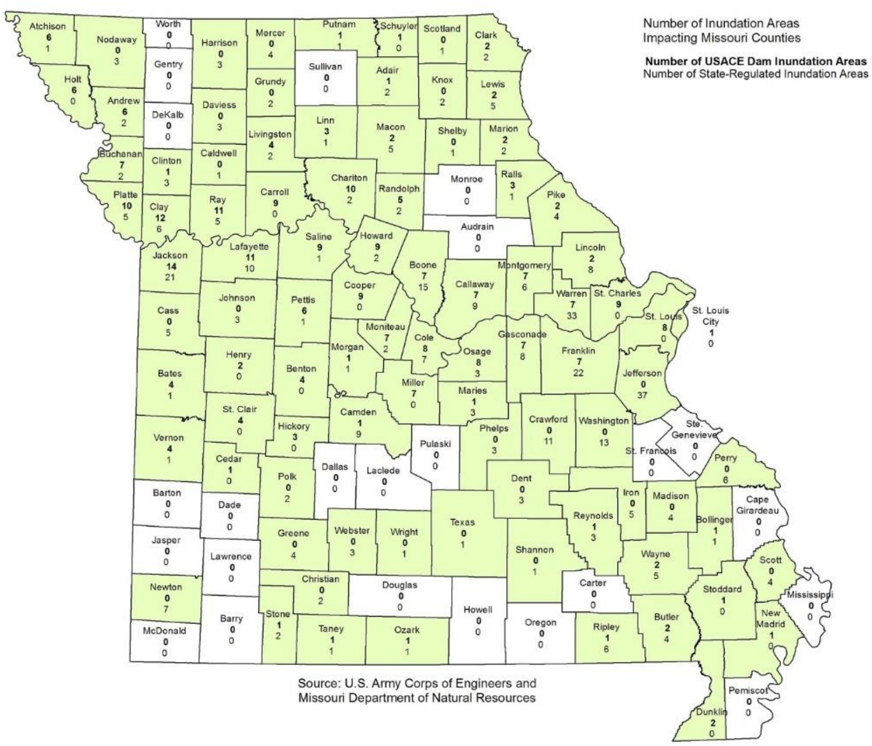
When a dam fails, the stored water can be suddenly released and have catastrophic effects on life and property downstream. Homes, bridges, and roads can be demolished in minutes. Residents near High Hazard or Significant Hazard dams should become familiar with the dam's emergency action plans, if available. Emergency plans written for dams include procedures for notification and coordination with local law

enforcement and other governmental agencies, information on the potential inundation area, plans for warning and evacuation, and procedures for making emergency repairs.

Persons at risk in inundation areas may include farm workers, hunters, anglers, hikers, campers and other recreationists. Livestock may also be endangered, and crops may be damaged. To complete a quantitative analysis of people and property vulnerable to dam failure in Missouri as well as estimate potential losses, this risk assessment relied on available inundation maps for state and federally-regulated dams. While this analysis does not capture vulnerability to failure of all dams in the state, it is the most comprehensive analysis possible at this time with the available data.

Figure 3.54 provides the number by county of all state and USACE-regulated dams in Missouri for which inundation areas were made available for the State Hazard Mitigation Plan Vulnerability Analysis.

Figure 3.54. State and Federally-regulated Dams with Provided Inundation Areas



For State-regulated Class 1 and Class 2 dams that have available inundation maps as well as USACE dams for which inundation maps were made available, GIS comparative analysis was accomplished against the building exposure data to determine the types, numbers, and estimated values of buildings at risk to dam failure. The building exposure data was based on the structure inventory data layer available from the Missouri Spatial Data Inventory Service (MSDIS). The available dam inundation areas were compared against the structure inventory to determine the numbers and types of structures at risk to dam failure. To calculate estimated values of buildings at risk, buildings values available in the HAZUS census block data were used to determine an average value for each property type. This average value per property type was then applied to the number of structures in dam inundation areas by type to calculate an overall estimated value of buildings at risk by type.

In addition to counts and values of structures at risk, an estimated population impacted for each county was calculated based on the number of residential properties in inundation areas multiplied by the average household size.

Appendix A provides the results of the inundation area analysis with the numbers and values of various types of structures, and population within the mapped inundation areas for State-Regulated Dams and USACE dams. **Figure 3.55** to **Figure 3.60** provide thematic maps of the analysis results for number of structures, value of structures, and population at risk.

Figure 3.55. Number of Structures in State-Regulated Dam Inundation Areas by County

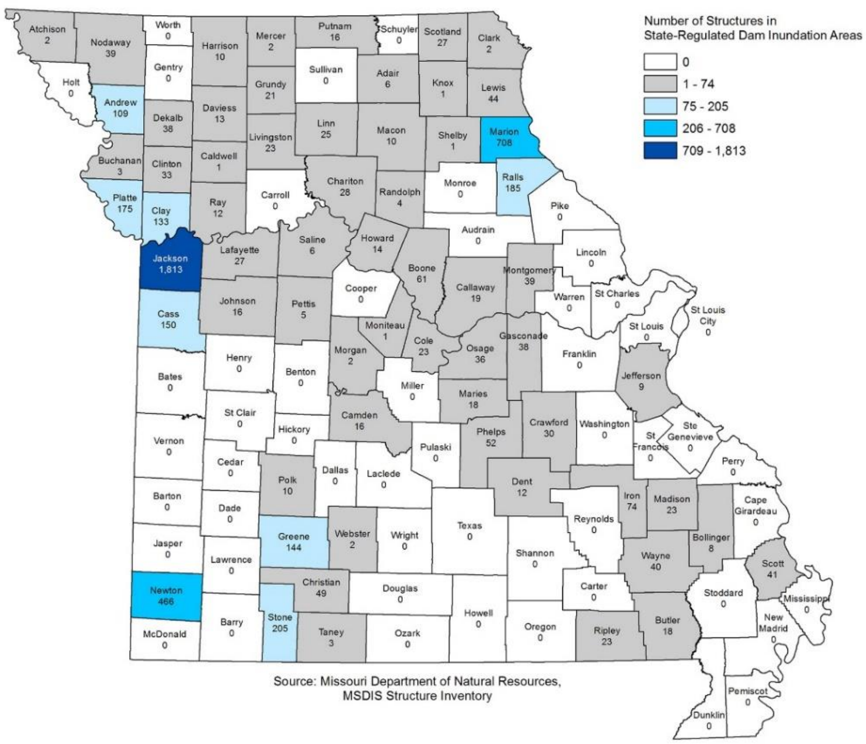


Figure 3.56. Value of Structures in State-Regulated Dam Inundation Areas by County

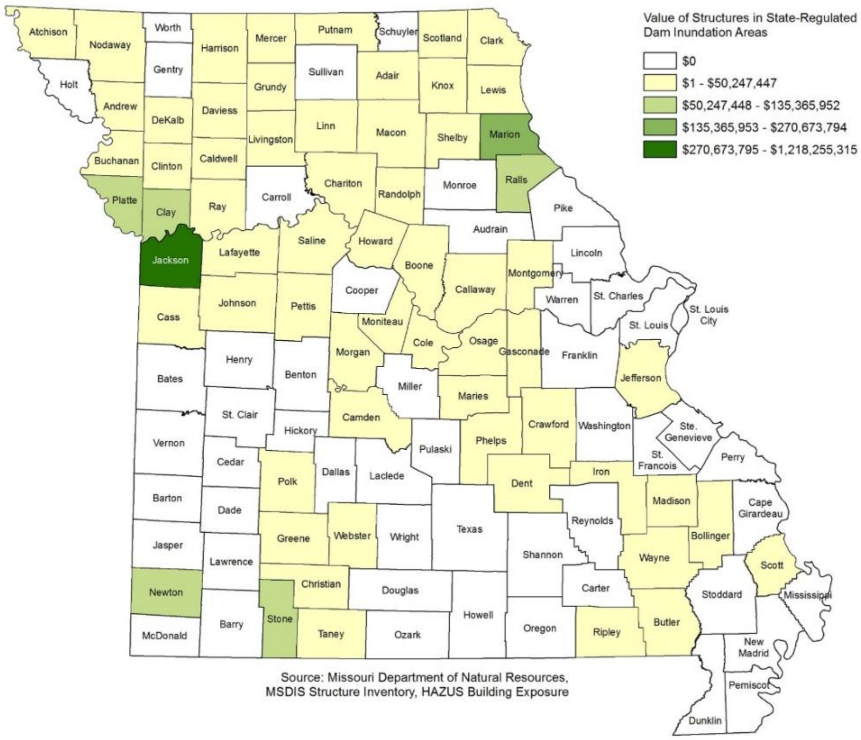


Figure 3.57. Number of Structures in USACE Dam Inundation Areas by County

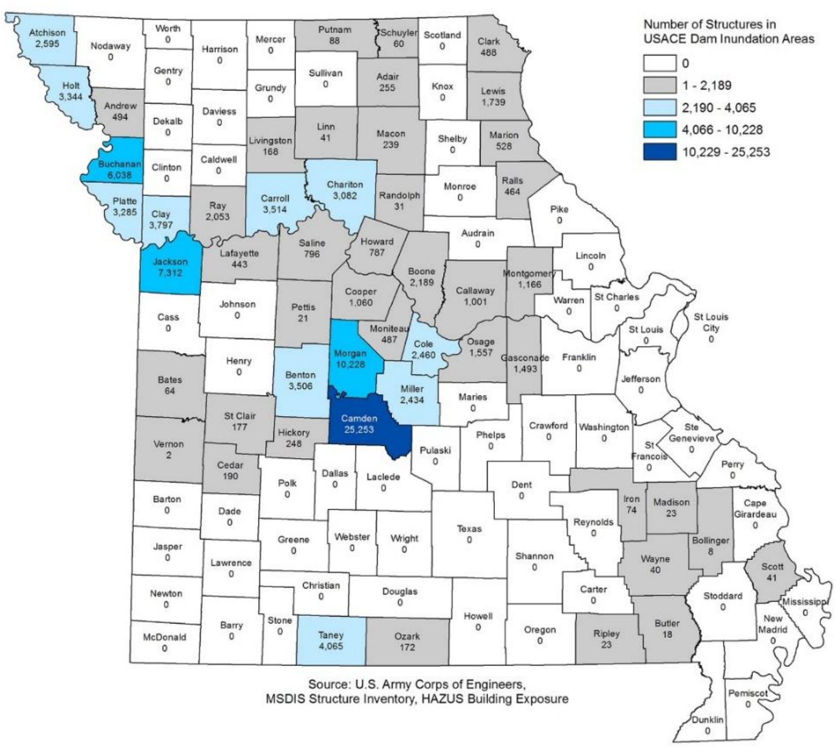


Figure 3.58. Value of Structures in USACE Dam Inundation Areas by County

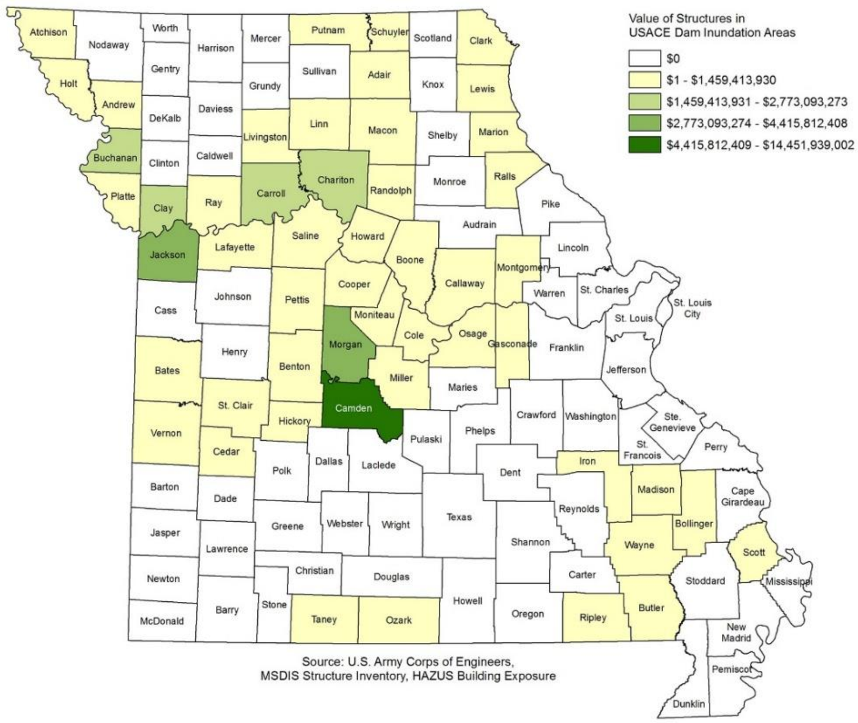


Figure 3.59 provides the estimated population at risk to dam failure based on the average household size and the number of residential structures at risk to dam inundation by county.

Figure 3.59. Population at Risk to Dam Failure in Available State-Regulated Inundation Areas

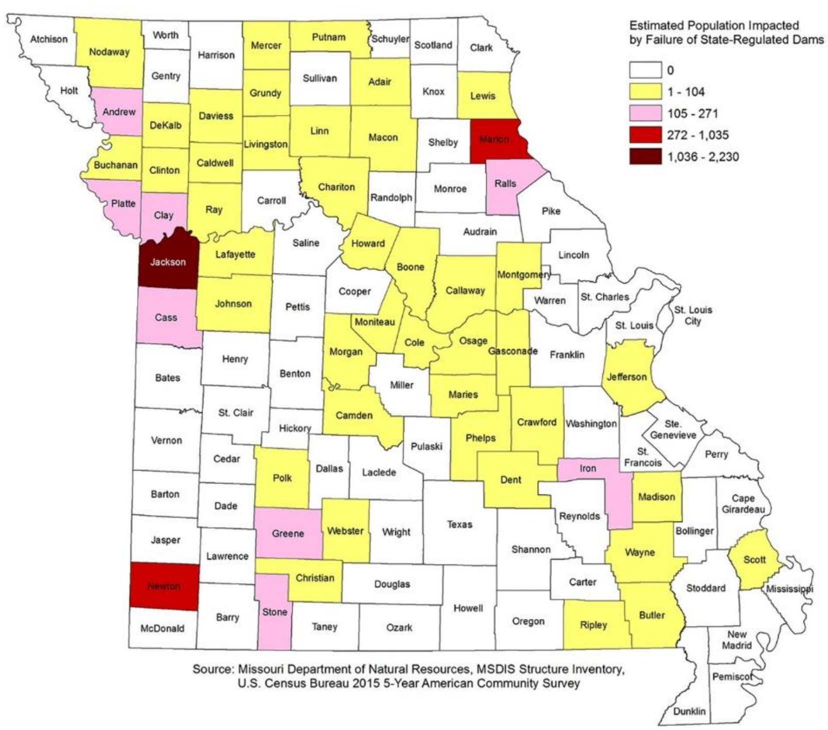
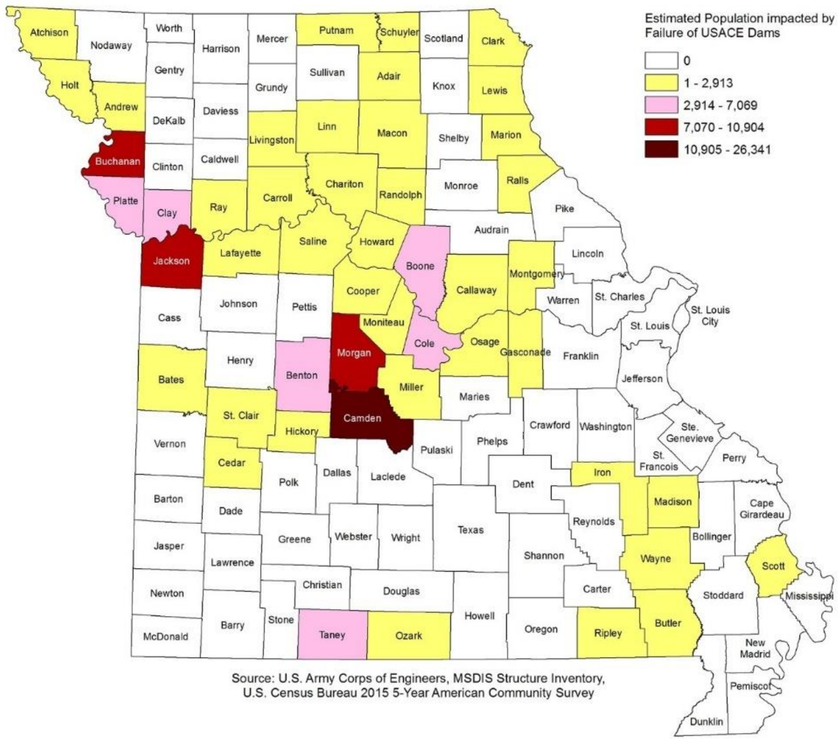


Figure 3.60. Population at Risk to Dam Failure in Available USACE Inundation Areas



State Estimates of Potential Losses

To determine state estimates of potential loss, a damage estimation of 20 percent of the total structure value in dam inundation areas was used. This damage amount is based on FIA depth-damage curves for a one-story structure with no basement flooded to two feet. **Table 3.44** provides the results.

Table 3.44. State Estimates of Potential Loss as a Result of Dam Failure (Combined State-Regulated and USACE)

County	Loss Estimates
Adair	$22,231,724
Andrew	$34,899,512
Atchison	$290,956,434
Bates	$9,726,759
Benton	$313,487,738
Bollinger	$2,602,443
Boone	$158,995,184
Buchanan	$674,457,803
Butler	$2,421,631
Caldwell	$44,983
Callaway	$60,010,203
Camden	$3,515,526,888
Carroll	$436,176,329

County	Loss Estimates
Cass	$11,888,977
Cedar	$13,243,755
Chariton	$587,616,402
Christian	$4,645,582
Clark	$67,560,447
Clay	$498,744,331
Clinton	$2,711,334
Cole	$183,691,870
Cooper	$63,066,397
Crawford	$1,413,161
Daviess	$1,136,741
Dekalb	$3,954,269
Dent	$1,354,732

County	Loss Estimates
Gasconade	$100,642,144
Greene	$12,217,968
Grundy	$1,080,122
Harrison	$474,734
Hickory	$14,992,800
Holt	$207,100,373
Howard	$47,032,758
Iron	$8,509,586
Jackson	$1,369,957,377
Jefferson	$510,899
Johnson	$994,560
Knox	$306,713
Lafayette	$23,836,030
Lewis	$140,517,854
Linn	$4,497,863
Livingston	$11,675,658
Macon	$12,726,469
Madison	$2,739,047
Maries	$1,088,744
Marion	$108,432,817
Mercer	$241,206
Miller	$205,436,699
Moniteau	$25,454,544
Montgomery	$64,785,355
Morgan	$997,073,759
Newton	$32,915,043
Nodaway	$2,759,890
Osage	$213,913,400
Ozark	$22,515,143
Pettis	$1,753,493
Phelps	$2,602,450
Platte	$376,561,015
Polk	$513,836
Putnam	$16,341,247
Ralls	$47,858,700
Randolph	$3,543,579
Ray	$170,765,010
Ripley	$548,701
Saline	$78,471,842
Schuyler	$9,912,274
Scotland	$4,643,060
Scott	$4,321,631
Shelby	$59,557
St Clair	$17,196,723
Stone	$17,113,762
Taney	$323,667,209
Vernon	$308,369
Wayne	$3,684,264
Webster	$99,295
Total	**$11,676,961,201**

It should be noted that dam failures are generally isolated incidents and do not often occur in conjunction with failure at additional dam sites. Since it is unknown which dams, if any might fail at any given time, this analysis provides for a state-wide view of dam failure. It is nearly certain that not all dams would fail simultaneously. So, this analysis should be viewed in light of these considerations.

Hazard Impact on Future Growth and Development

Of the top 10 counties with highest percent increase in populations, the following are also in the top 10 for potential population impacted by dam failure: Boone, Clay, and Platte. Of the top 10 counties with highest number increase in housing units, the following are also in the top 10 for number of structures impacted by dam failure: Jackson, Clay, and Platte. If growth in these counties is occurring in dam inundation areas, the vulnerable populations and structures will increase as well.

Risk Summary

Dam breaks are caused most often by failure of the structure itself. However, flooding is the most common hazard associated with dam failure. Prolonged rains and flooding can saturate earthen dams, for example, producing much the same breaching effect as occurs with earthen levees. Flooding can also result in overtopping of dams when the spillway and reservoir storage capacities are exceeded. A large slide may develop in either the upstream or downstream slope of the embankment and threaten to release the impounded water. Complete structural collapse can occur, especially as a result of an earthquake.

Actual dam failure can result not only in loss of life, but also considerable loss of capital investment, loss of income, and property damage. Loss of the reservoir itself can cause hardship for those dependent on it for their livelihood or water supply.

The majority of dams in Missouri are less than 35 feet high and/or not owned by a federal entity and are therefore not regulated by the State or a federal entity. While the State has encouraged dam owners to have these unregulated dams inspected, the MoDNR lacks the authority to assess the condition of these dams and any downstream hazards.

Flood risk is a shared responsibility including communities within the floodplain, owners and operators of dams and levees, owners and operators of infrastructure within the floodplain and agencies with jurisdiction for emergency management and evacuation authority. Local residents are expected to know their risk. One key public message is that flood risk mitigation projects (including dams and levees) reduce risk; they do not eliminate it.

Problem Statement:

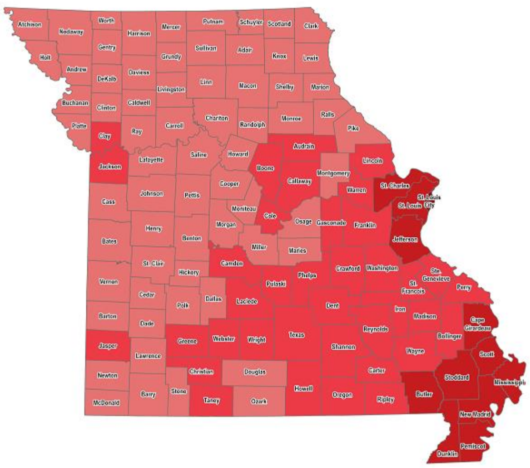
Using the indicators of potential residential losses due from either State or USACE dam failure, the top five counties affected are Jackson, Greene, Clay, Boone and Cass counties. Mitigation efforts and dollars would most likely prove most successful in these areas of highest impact.

2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023. Note that the inundation layers are only available through a direct request to MODNR.

3.3.4. Earthquake

Description

Earthquakes are defined as shifts in the earth's crust causing the surface to become unstable. This instability can manifest itself in intensity from slight tremors to large shocks. The duration can be from a few seconds up to five minutes. The period of tremors (and shocks) can last up to several months. The larger shocks can cause ground failure, landslides, liquefaction, uplifts, and sand blows.

Vulnerability	Extent/Range of Intensity
	The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. The Richter Magnitude Scale is used to quantify the magnitude or strength of the seismic energy released by an earthquake. Another measure of earthquake severity is Intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity Scale.

Probability	Severity	Location
65% 32 events in 49 years	High	Statewide, predominately Bootheel area of State

State Vulnerability Overview

According to MoDNR's Missouri Geological Survey, damage from earthquakes in the New Madrid Seismic Zone will vary depending on the earthquake magnitude, the character of the land, and the degree of urbanization. The Bootheel area is dominantly rural with scattered small to medium-sized towns. Damage to the land could be extensive and significantly affect the area's farming industry. The more distant, densely populated urban area of St. Louis is not likely to have damage to the land, but its huge stock of structures and their contents could receive significant damage from shaking and earthquake-triggered landslides and sinkhole collapse. Shaking would be most severe to development built on thick, clay-rich soils. Roads and railroads in southeast Missouri and Saint Louis area could be severely damaged by earthquake triggered slope failures, rockfalls, and liquefaction.

Changing Future Conditions Considerations

Scientists are beginning to believe there may be a connection between changing climate conditions and earthquakes. Changing ice caps and sea-level redistribute weight over fault lines, which could potentially have an influence on earthquake occurrences. However, currently no studies quantify the relationship to a high level of detail, so recent earthquakes should not be linked with climate change. While not conclusive, early research suggests that more intense earthquakes and tsunamis may eventually be added to the adverse consequences that are caused by changing future conditions.

Risk Summary/Problem Statement
Mitigation efforts should be concentrated in Butler, Cape Girardeau, Dunklin, Mississippi, New Madrid, Pemiscot, Scott, Stoddard, and St. Louis counties and the City of St. Louis.

Description/Location

Earthquakes are defined as shifts in the earth's crust causing the surface to become unstable. This instability can manifest itself in intensity from slight tremors to large shocks. The duration can be from a few seconds up to five minutes. The period of tremors (and shocks) can last up to several months. The larger shocks can cause ground failure, landslides, liquefaction, uplifts, and sand blows.

The earth's crust is made up of gigantic plates, commonly referred to as tectonic plates. These plates form what is known as the lithosphere, which varies in thickness from 6.5 miles (beneath oceans) to 40 miles (beneath mountain ranges) and has an average thickness of 20 miles. These plates "float" over a partly melted layer of crust called the asthenosphere. These plates are in constant motion, and areas where one plate joins another are referred to as "plate boundaries." Areas where the plates are moving toward each other are called convergent plate boundaries, areas where they are moving away from each other are called divergent plate boundaries, and areas where they are neither moving away nor towards each other are called transform boundaries. The San Andreas Fault in California is one such transform boundary where the Pacific Plate is moving to the north while the North American Plate is moving to the west.

Plate movements release built-up energy in the form of earthquakes, tremors, and volcanic activity. Fault lines such as the San Andreas come all the way to the surface and can be readily seen and identified. Some fault lines do not come all the way to the surface, yet all faults store and release energy when they move. Many of the faults in the central United States are characterized this way.

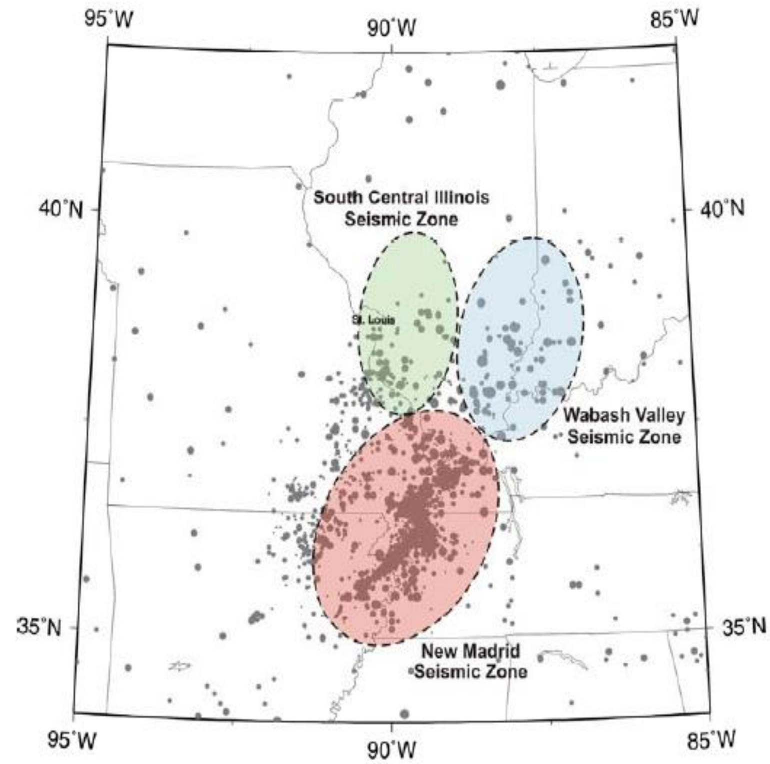
Subterranean faults, faults that do not make it to the surface, were formed many millions of years ago on or near the surface of the earth. Subsequent to that time, these ancient faults subsided, while the adjacent areas were pushed up. As this fault zone (also known as a rift) sank, sediments filled in the lower areas. Under pressure, sediments hardened into limestone, sandstone, and shale, thus burying the rifts. With the pressure on the North Atlantic Ridge affecting the eastern side of the North American Plate, and the movements along the San Andreas Fault by the Pacific Plate, one such rift system in the Mississippi embayment has reactivated. This particular rift system is now called the Reelfoot Rift.

Eight earthquake seismic zones are located in the central United States, two of which are located in Missouri. The most active zone is the New Madrid Seismic Zone, which is also the most active seismic area in the United States east of the Rocky Mountains according to the U.S. Geological Survey. The New Madrid Zone is by some measures as high a risk for tremors as seismic zones in California. It runs from northern Arkansas through southeast Missouri and western Tennessee and Kentucky to the Illinois side of the Ohio River Valley (see **Figure 3.61)**.

The southeastern (Bootheel) section of Missouri is most susceptible to earthquakes because it overlies the New Madrid Seismic Zone. It is at risk to strong ground motions and has a high potential for soil liquefaction due to the presence of sandy, loosely consolidated sediments and a high-water table. The immediate vicinity of the Ozarks is also at risk from earthquakes in the New Madrid Seismic Zone because, like in the Bootheel, subsurface conditions of the Mississippi and Missouri river valleys tend to amplify earthquake ground shaking. Earthquake hazards in the western part of the State also exist

because of the historical earthquakes in eastern Kansas and Nebraska. No area of Missouri is immune from the danger of earthquakes. Minor, but potentially damaging, earthquakes can occur anywhere in the State.

Figure 3.61. New Madrid, South Central Illinois, and Wabash Valley Seismic Zones



Source: Rogers, Karadeniz, and Cramer (in press 2007)

In addition to the New Madrid Seismic Zone, other seismic zones that affect Missourians include the Wabash Valley Seismic Zone, the South-Central Illinois Seismic Zone, and the Nemaha Uplift. The Wabash and Illinois seismic zones are not as active as the New Madrid Seismic Zone based on microseismic activity, but they are considered capable of producing earthquakes in the range of M 6.0 to 6.8. An earthquake of this magnitude on the South-Central Illinois Seismic Zone could potentially cause more damage to the St. Louis metropolitan area than a New Madrid Seismic Zone event because it is closer to the area. The Nemaha Uplift is of concern to Missourians because it runs parallel to the Missouri/Kansas border from Lincoln, Nebraska, to Oklahoma City, Oklahoma. Earthquakes from the Nemaha Uplift are not as severe as those associated with the historic New Madrid Seismic Zone.

Large earthquakes in Missouri could trigger additional hazards such as soil liquefaction, lateral spreading, landslides, and sinkhole collapse (specifically in the karst topography present in much of southeast Missouri). Liquefaction is a site soil response to strong earthquake ground motion. Strong earthquake waves cause water pressure to increase within sandy soils; force sand grains apart, and the material will behave as a dense liquid. Sandblows form in the areas where liquefied sand is overlain by heavier clay rich silts, causing a geyser-like eruption of sand onto the land surface. Liquefaction causes land to lose its load-bearing capacity, which can lead to differential settlement and associated building foundation failures. Lateral spreading can occur even on gentle slopes and seriously damage buried utilities and road networks. Landslides could be triggered in steep slopes and road cuts through unstable

geologic materials, potentially damaging and closing roads and railroads. As noted earlier, these risk areas and any identified mitigation fall under the jurisdiction of MoDOT. Earthquake shaking will exacerbate existing problems and cause even more slides where none have existed before. It is possible that housing developments on certain shale bedrock units could be affected by landslides as well, with potentially catastrophic results.

Extent / Range of Intensity

The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. Seismologists have developed several magnitude scales; one of the first was the Richter Scale, developed in 1932 by the late Dr. Charles F. Richter of the California Institute of Technology. The Richter Magnitude Scale is used to quantify the magnitude or strength of the seismic energy released by an earthquake. The moment magnitude scale (abbreviated as MMS; denoted as M_W or M) is used by seismologists to measure the size of earthquakes in terms of the energy released. The scale was developed in the 1970s to succeed the Richter magnitude scale. Even though the formulas are different, the new scale retains a similar continuum of magnitude values to that defined by the older one. As with the Richter magnitude scale, an increase of one step on this logarithmic scale corresponds to a 101.5 (about 32) times increase in the amount of energy released, and an increase of two steps corresponds to 103 (1,000) times increase in energy. Thus, an earthquake of Mw of 7.0 releases about 32 times as much energy as one of 6.0 and 1,000 times that of 5.0.

Another measure of earthquake severity is Intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity Scale. **Table 3.45** describes the typical effects and Intensities associated with earthquakes of various magnitudes. The intensity and effects depend on several factors (earthquake depth, epicenter location, site geology, population density, to name a few) and can vary widely.

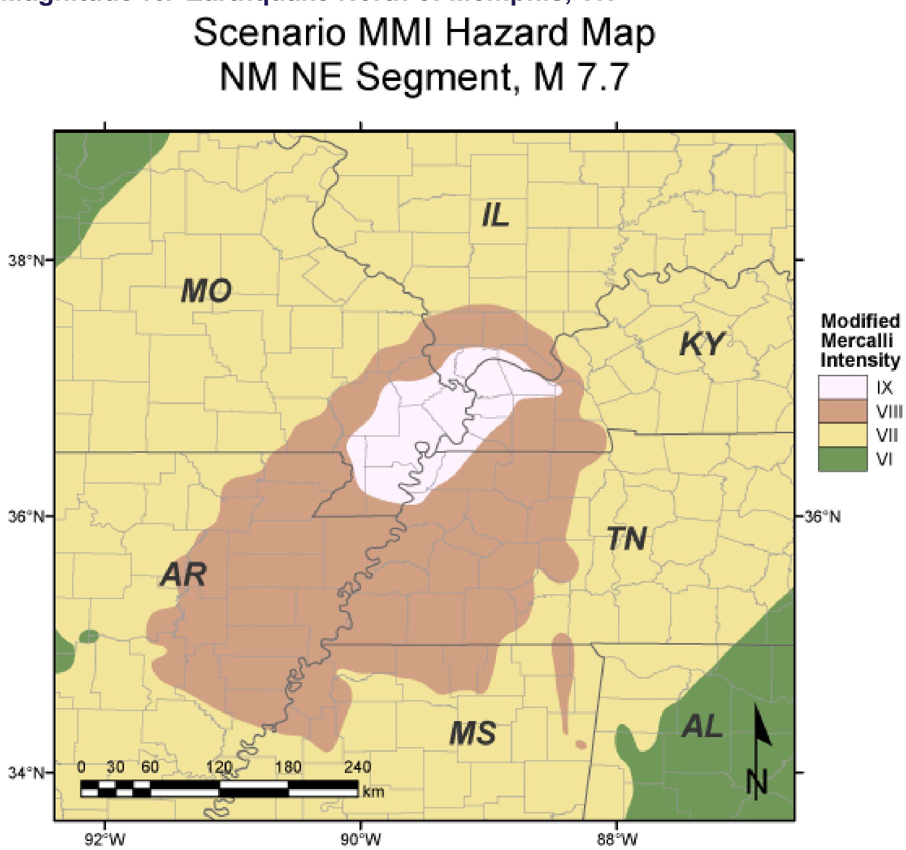
Table 3.45. Richter Magnitude and Modified Mercalli Intensity Scales and Effects

Magnitude	Mercalli Intensity	Effects
Less than 2.0	I	Microearthquakes, not felt or rarely felt; recorded by seismographs.
2.0-2.9	I	Felt slightly by some people; damages to buildings.
3.0-3.9	II to III	Often felt by people; rarely causes damage; shaking of indoor objects noticeable.
4.0-4.9	IV to V	Noticeable shaking of indoor objects and rattling noises; felt by most people in the affected area; slightly felt outside; generally, no to minimal damage.
5.0-5.9	VI to VII	Can cause damage of varying severity to poorly constructed buildings; at most, none to slight damage to all other buildings. Felt by everyone.
6.0-6.9	VII to IX	Damage to a moderate number of well-built structures in populated areas; earthquake-resistant structures survive with slight to moderate damage; poorly designed structures receive moderate to severe damage; felt in wider areas; up to hundreds of miles/kilometers from the epicenter; strong to violent shaking in epicentral area.

Magnitude	Mercalli Intensity	Effects
7.0-7.9	VIII or higher	Causes damage to most buildings, some to partially or completely collapse or receive severe damage; well-designed structures are likely to receive damage; felt across great distances with major damage mostly limited to 250 km from epicenter.
8.0-8.9	VIII or higher	Major damage to buildings, structures likely to be destroyed; will cause moderate to heavy damage to sturdy or earthquake-resistant buildings; damaging in large areas; felt in extremely large regions.
9.0 and Greater	VIII or higher	At or near total destruction - severe damage or collapse to all buildings; heavy damage and shaking extends to distant locations; permanent changes in ground topography.

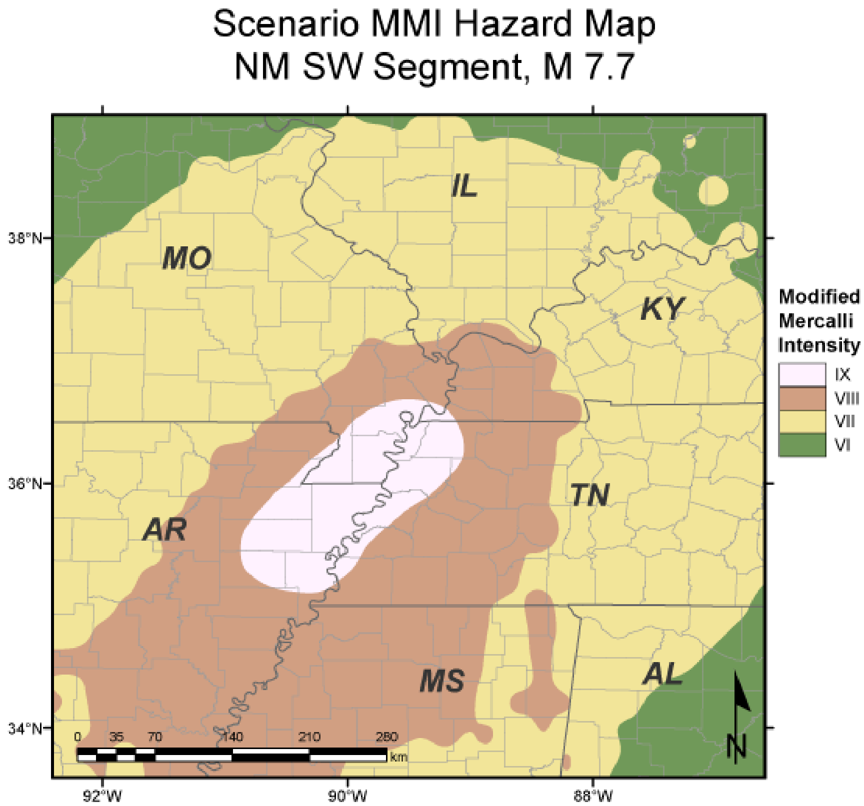
Figure 3.62 through Figure 3.65 present the projected Modified Mercalli intensities for a variety of earthquake scenarios developed for a National Exercise in 2011. These scenarios address earthquakes along the New Madrid Seismic Zone, Wabash Valley Seismic Zone, and Southern Illinois Basin. Based on this information the highest extent earthquake in Modified Mercalli Intensity could be Intensity IX in the extreme southeastern bootheel region counties.

Figure 3.62. Projected Modified Mercalli Intensity – New Madrid Seismic Zone Magnitude 7.7 Earthquake North of Memphis, TN



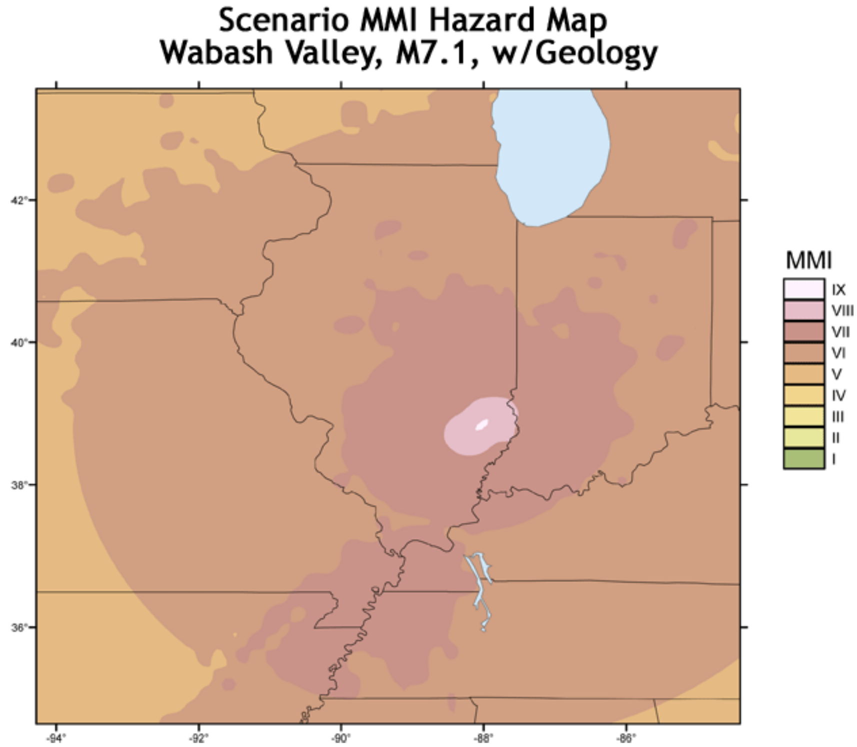
Source: https://earthquake.usgs.gov/scenarios/related.php

Figure 3.63. Projected Modified Mercalli Intensity – New Madrid Seismic Zone Magnitude 7.7 Earthquake Northwest of Memphis, TN



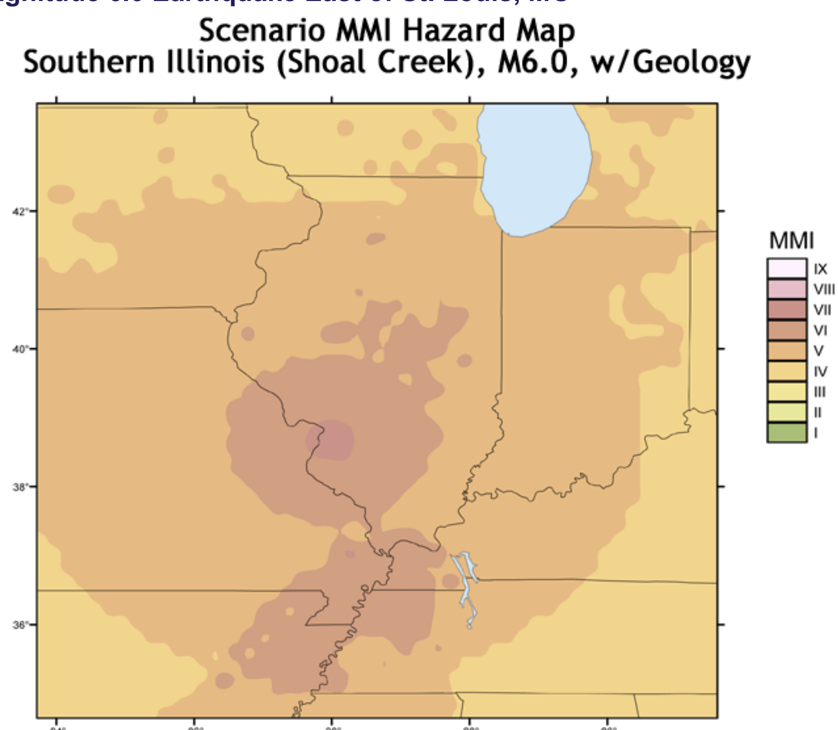
Source: https://earthquake.usgs.gov/scenarios/related.php

Figure 3.64. **Projected Modified Mercalli Intensity – Wabash Valley Seismic Zone Magnitude 7.1 Earthquake Near Vincennes, IN**



Source: https://earthquake.usgs.gov/scenarios/related.php

Figure 3.65. **Projected Modified Mercalli Intensity – Shoal Creek/Southern Illinois Basin Magnitude 6.0 Earthquake East of St. Louis, MO**



Source: https://earthquake.usgs.gov/scenarios/related.php

Previous Occurrences

Several earthquakes have affected Missouri in the past. Small earthquakes occur often in Missouri. About 200 are detected every year in the New Madrid Seismic Zone. Most can only be detected by sensitive instruments, but southeast Missouri experiences an earthquake once or twice every 18 months that is strong enough to crack plaster in buildings.

The most severe earthquakes occurred in the New Madrid Seismic Zone during a period between December 16, 1811, and March 12, 1812. The earthquakes on December 16, 1811 (M7.5), January 23, 1812 (M7.3) and February 7, 1812 (M7.5), rank among the United States' largest earthquakes. The shocks from these earthquakes could be easily felt as far away as Detroit, Michigan, and Charleston, South Carolina. The area between the St. Francois River and Mississippi River south of New Madrid to Marked Tree, Arkansas, showed numerous sand blows from liquefaction. Because there were no seismographs in North America at that time, and very few people in the New Madrid region, the estimated magnitudes of this series of earthquakes vary considerably and depend on modern researchers' interpretations of journals, newspaper reports, and other accounts of the ground shaking and damage. The magnitudes of the three principal earthquakes of 1811-1812 described previously are the preferred values taken from research involved with producing the 2014 USGS National Seismic Hazard Map (source https://www.usgs.gov/programs/earthquake-hazards/science/national-seismic-hazard-model).

Areas uplifted as well as subsided (dropped) along the Mississippi River during the 1811-1812 events, creating new landforms. The area around Tiptonville, Tennessee, formed a dome (uplift of several yards). Immediately adjacent to the Tiptonville Dome, an area subsided to form a lake 18 miles long and 5 miles wide. It is now known as Reelfoot Lake and is a tourist and recreation area. Ground failure and landslides were apparent throughout the bluffs (Chickasaw Bluffs) alongside the Mississippi River in Kentucky and Tennessee. Many fissures were made throughout the region, and one local observer recorded that the earth seemed to be rolling in waves a few feet in height. These swells would burst, leaving wide and long fissures. The damage to the area was so severe that Congress passed, and President James Madison signed into law, the first disaster relief act, giving government lands in other territories to people wanting to move out of the area.

The following is excerpted directly from Carl A. von Hake's "Missouri Earthquake History" in Earthquake Information Bulletin, Volume 6, Number 3, May–June 1974 and provides a more detailed perspective of the 1811-1812 events:

Whatever the seismic history of the region may have been before the first Europeans arrived, after December 16, 1811, there could be no doubt about the area's potential to generate severe earthquakes. On that date, shortly after 2 AM, the first tremor of the most violent series of earthquakes in the United States history struck southeast Missouri. In the small town of New Madrid, about 290 kilometers south of St. Louis, residents were aroused from their sleep by the rocking of their cabins, the cracking of timbers, the clatter of breaking dishes and tumbling furniture, the rattling of falling chimneys, and the crashing of falling trees. A terrifying roaring noise was created as the earthquake waves swept across the ground. Large fissures suddenly opened and swallowed large quantities of river and marsh water. As the fissures closed again, great volumes of mud and sand were ejected along with the water.

The earthquake generated great waves on the Mississippi River that overwhelmed many boats and washed others high upon the shore. The waves broke off thousands of trees and carried them into the

river. High riverbanks caved in, sand bars gave way, and entire islands disappeared. The violence of the earthquake was manifested by great topographic changes that affected an area of 78,000 to 130,000 square kilometers.

On January 23, 1812, a second major shock, seemingly more violent than the first, occurred. A third great earthquake, perhaps the most severe of the series, struck on February 7, 1812.

The three main shocks probably reached intensity XII, the maximum on the Modified Mercalli scale, although it is difficult to assign intensities, due to the scarcity of settlements at the time. Aftershocks continued to be felt for several years after the initial tremor. Later evidence indicates that the epicenter of the first earthquake (December 16, 1811) was probably in northeast Arkansas. Based on historical accounts, the epicenter of the February 7, 1812, shocks was probably close to the town of New Madrid.

Although the death toll from the 1811-12 series of earthquakes has never been tabulated, the loss of life was very slight. It is likely that if at the time of the earthquakes the New Madrid area had been as heavily populated as at present, thousands of persons would have perished. The main shocks were felt over an area covering at least 5,180,000 square kilometers. Chimneys were knocked down in Cincinnati, Ohio, and bricks were reported to have fallen from chimneys in Georgia and South Carolina. The first shock was felt distinctly in Washington, D.C., 700 miles away, and people there were frightened badly. Other points that reported feeling this earthquake included New Orleans, 804 kilometers away; Detroit, 965 kilometers away; and Boston, 1,769 kilometers away.

The New Madrid seismic zone has experienced numerous earthquakes since the 1811-12 series, and at least 35 shocks of intensity V or greater have been recorded in Missouri since 1811. Numerous earthquakes originating outside of the State's boundaries have also affected Missouri. Five of the strongest earthquakes that have affected Missouri since the 1811-12 series are described below.

On January 4, 1843, a severe earthquake in the New Madrid area cracked chimneys and walls at Memphis, Tennessee. One building reportedly collapsed. The earth sank at some places near New Madrid; there was an unverified report that two hunters were drowned during the formation of a lake. The total felt area included at least 1,036,000 square kilometers.

The October 31, 1895, earthquake near Charleston, Missouri, probably ranks second in intensity to the 1811-12 series. Every building in the commercial area of Charleston was damaged. Cairo, Illinois, and Memphis, Tennessee, also suffered significant damage. Near Charleston, 4 acres of ground sank and a lake was formed. The shock was felt over all or portions of 23 states and at some places in Canada.

A moderate earthquake on April 9, 1917, in the Ste. Genevieve–St. Mary's area was reportedly felt over a 518,000 square kilometer area from Kansas to Ohio and Wisconsin to Mississippi. In the epicentral area people ran into the street, windows were broken, and plaster cracked. A second shock of lesser intensity was felt in the southern part of the area.

The small railroad town of Rodney, Missouri, experienced a strong earthquake on August 19, 1934. At nearby Charleston, windows were broken, chimneys were overthrown or damaged, and articles were knocked from shelves. Similar effects were observed at Cairo, Mounds and Mound City, Illinois, and at Wickliff, Kentucky. The area of destructive intensity included more than 596 square kilometers.

The November 9, 1968, earthquake centered in southern Illinois was the strongest in the central United States since 1895. The magnitude 5.5 shock caused moderate damage to chimneys and walls at Hermann, St. Charles, St. Louis, and Sikeston, Missouri. The felt areas include all or portions of 23 states.

Along the Nemaha Seismic Zone, an earthquake of 3.1 Richter magnitude occurred on March 31, 1993, close to the Cooper Nuclear Power Station in Brownville, Nebraska. Another 3.1 occurred on March 23, 2007, near Effingham, Kansas. No damage resulted from either event; however, the earthquake was felt across the Missouri River into Missouri.

Most recently, on November 18, 2021, a 4.0 magnitude earthquake was recorded around 9 p.m. Wednesday in Wayne County, with the epicenter near Williamsville. The Missouri Department of Public Safety (DPS) said in a statement online that no injuries were immediately reported, but that some people reported pictures falling off of walls. DPS noted that people as far away as St. Louis, Springfield and Memphis, Tennessee, reported feeling the earthquake. The U.S. Geological Survey estimated the earthquake occurred at a depth of about 10.6 miles.

From 1811-2021 in the central united states, there have been 56 recorded earthquakes with a magnitude greater than 4. Of those 56 events, 5% have been over M7, 4% have a recorded magnitude of 6-6.9, 34% have a recorded magnitude of 5-5.9, and the remaining 57% have a recorded magnitude of 4-4.9. **Table 3.46** lists moderate/large earthquakes in the Central United States.

Table 3.46. Earthquakes M>4 in the Central United States

Date	Locality	Magnitude	Maximum Intensity	Source Zone
December 16, 1811	New Madrid, Missouri	7.5	XII	New Madrid Fault
January 23, 1812	New Madrid, Missouri	7.3	XII	New Madrid Fault
February 7, 1812	New Madrid, Missouri	7.5	XII	New Madrid Fault
June 9, 1838	Southern Illinois	5.7	VI	Illinois Basin
January 4, 1843	Western Tennessee	6.3	VIII	New Madrid Fault
Unknown, 1860	Central Minnesota	5.0	Unknown	Colorado Lineament
August. 17, 1865	Southeastern Missouri	5.3	VII	New Madrid Fault
April 24, 1867	Lawrence, Kansas	5.1	VII	Nemaha Uplift
June 18, 1875	Western Ohio	5.3	VII	Cincinnati Arch
November 15, 1877	Eastern Nebraska	5.0	VII	Nemaha Uplift
October 22, 1882	Arkansas, Texas	5.5	VI–VII	Ouchita, Wichita Fault
July 26, 1891	Illinois, Indiana	5.9	VI	Wabash Valley Fault
October 31, 1895	Charleston, Missouri	6.7	VIII	New Madrid Fault
May 26, 1909	Illinois	5.1	VII	Cincinnati Arch
April 9, 1917	Eastern Missouri	5.0	VI	St. Francois Uplift
March 8, 1937	Western Ohio	5.0	VII–VIII	Cincinnati Arch
April 9, 1952	Enid, Oklahoma	5.1	VII	Nemaha Uplift
November 9, 1968	South Central Illinois	5.5	VII	Wabash Valley Fault
January 8, 1974	Tennessee	4.1	IV-V	New Madrid Fault

Date	Locality	Magnitude	Maximum Intensity	Source Zone
April 3, 1974	Illinois	4.5	IV-V	Wabash Valley Fault
May 13, 1974	Missouri	4.3	IV-V	New Madrid Fault
June 5, 1974	Illinois	4	IV-V	South Central Fault
June 13, 1975	8 km SW of Lilbourn, Missouri	4.3	IV-V	New Madrid Fault
March 24, 1976	Marked Tree, Arkansas	5.0	V–VI	New Madrid Fault
March 25, 1976	8 km NW of Marked Tree, Arkansas	5	VI	New Madrid Fault
December 11, 1976	Missouri	4.2	IV-V	South Central Fault
July 27, 1980	North Central Kentucky	5.2	VII	Cincinnati Arch
August 7, 1981	11 km SE of Newbern, Tennessee	4	IV-V	New Madrid Fault
January 21, 1982	11 km NW of Vilonia, Arkansas	4.1	IV-V	New Madrid Fault
March 1, 1982	15 km NE of Vilonia, Arkansas	4.1	IV-V	New Madrid Fault
May 15, 1983	9 km ENE of Highland, Illinois	4.3	IV-V	South Central Fault
January 31, 1986	Anna, Ohio	5.0	VI	Cincinnati Arch
June 9, 1987	Lawrenceville, Illinois	5.2	V–VI	Wabash Valley Fault
June 13, 1987	10 km W of Lilbourn, Missouri	4.1	IV-V	New Madrid Fault
September 29, 1987	6 km SSE of Cairo, Illinois	4.3	IV-V	New Madrid Fault
April 27, 1989	4 km E of Steele, Missouri	4.3	IV-V	New Madrid Fault
May 3, 1991	Risco, Missouri	4.6	IV–V	New Madrid Fault
May 4, 1991	12 km E of Malden, Missouri	4.5	IV-V	New Madrid Fault
May 4, 2001	Conway, Arkansas	4.4	VI	Ouchita, Wichita Fault
June 18, 2002	Evansville, Indiana	4.6	VI	Wabash Valley Fault
November 3, 2002	O’Neill, Nebraska	4.3	V	Nemaha Uplift
April 30, 2003	1 km N of Blytheville, Arkansas	4	IV-V	New Madrid Fault
June 6, 2003	Cairo, Illinois	4.0	VI	New Madrid Fault
August 16, 2003	West Plains, Missouri	4.0	V	New Madrid Fault
June 28, 2004	Ottawa, Illinois	4.2	VI	Illinois Basin
February 10, 2005	Blytheville, Arkansas	4.1	V	New Madrid Fault
May 1, 2005	Blytheville, Arkansas	4.1	V	New Madrid Fault
June 2, 2005	Dyersburg, Tennessee	4.0	IV	New Madrid Fault
April 18, 2008	Gards Point, IL	5.2	VII	Wabash Valley Fault
April 18, 2008	Ogden, IL	4.6	VI	Wabash Valley Fault

Date	Locality	Magnitude	Maximum Intensity	Source Zone
April 21, 2008	Gards Point, IL	4.0	V	Wabash Valley Fault
April 21, 2008	Ogden, IL	4.2	V	Wabash Valley Fault
October 11, 2010	10 km NE of Greenbrier, Arkansas	4.1	IV-V	New Madrid Fault
February 18, 2011	4 km NNE of Greenbrier, Arkansas	4.1	IV-V	New Madrid Fault
February 28, 2011	4 km NE of Greenbrier, Arkansas	4.7	IV-V	New Madrid Fault
November 18, 2021	7 km S of Williamsville, Missouri	4.0	V	New Madrid Fault
There have been no earthquakes greater than 4.0 since November 2021 registered in Missouri.				

Source: State Hazard Analysis, July 2018, and USGS Earthquake Catalog, https://earthquake.usgs.gov/earthquakes/search/

Table 3.47 is based on a USGS data query of any recent quakes in the Central United States recorded since 1973. Earthquakes in the region occur every year, though most of them are below M 4.0. Thirty-two earthquakes greater than or equal to M 4.0 have occurred in this timeframe.

Table 3.47. USGS Recorded Events by Magnitude in Central United States

	Magnitude		
Year	**2.5-2.9**	**3-3.9**	**4>**
1973-1979	43	30	8
1980-1989	142	77	8
1990-1999	105	36	3
2000-2009	144	23	9
2010	51	14	1
2011	132	38	2
2012	20	6	0
2013	34	5	**0**
2014	22	5	0
2015	36	12	0
2016	23	6	0
2017	28	11	0
2018	25	3	0
2019	47	10	0
2020	46	4	0
2021	39	7	1
Totals	**937**	**287**	**32**

Source: USGS Earthquake Events Database, Accessed October 2022

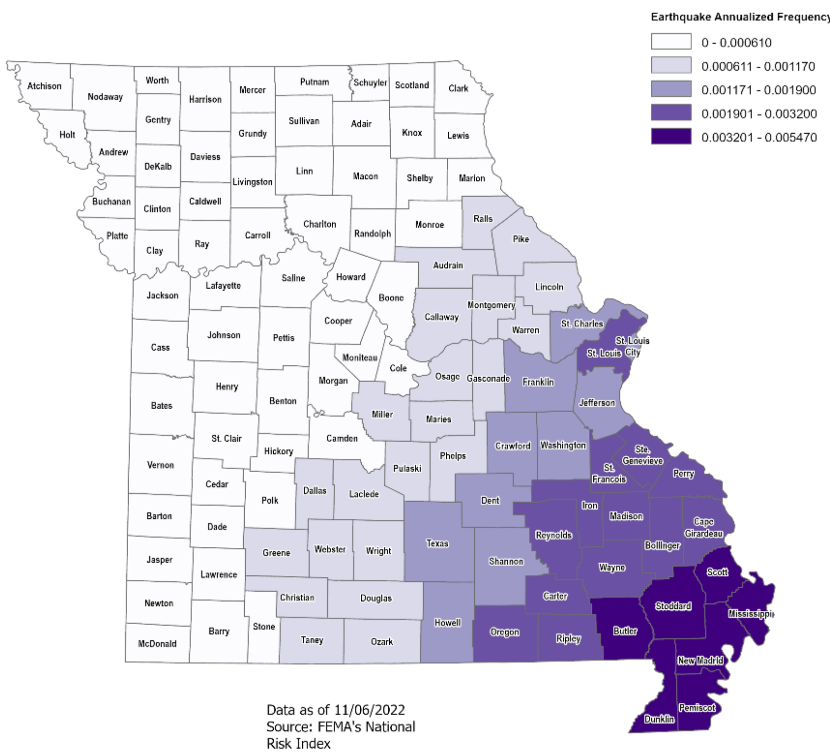
Probability of Future Hazard Events

There have been 32 recorded earthquake events greater than or equal to M 4.0 in the 49-year period from 1973 to 2021. According to this data, annual probability calculates to a 65 percent. Additionally, the USGS estimated in 2006 that the probability of a repeat of the 1811–1812 earthquakes (magnitude

7.5–8.0) was 7–10% in a 50-year time period (Source: http://pubs.usgs.gov/fs/2006/3125*).* Given the historical frequency of earthquake events, this hazard is determined to have a high probability of occurrence within the State.

FEMA's National Risk Index has calculated the annualized frequency of earthquake events. This value represents the area-weighted probability of earthquake occurrences, in events, (at least minor-damage shaking) impacting a location in a given year. The annualized frequency is calculated at the county level, see **Figure 3.66**.

Figure 3.66. Earthquake Annualized Frequency



Changing Future Conditions Considerations

Scientists are beginning to believe there may be a connection between changing climate conditions and earthquakes. Changing ice caps and sea-level redistribute weight over fault lines, which could potentially have an influence on earthquake occurrences. However, currently no studies quantify the relationship to a high level of detail, so recent earthquakes should not be linked with climate change. While not conclusive, early research suggests that more intense earthquakes and tsunamis may eventually be added to the adverse consequences that are caused by changing future conditions.

State Vulnerability Overview

The impacts and severity of earthquakes on Missouri can be significant. The New Madrid earthquakes of 1811–1812 are among the largest that have happened on the North American continent. Although losses were limited because of the sparse population of the time, many Native Americans died and property was damaged to the point that resettlement became a national policy.

The most important direct earthquake hazard is ground shaking. Ground shaking affects structures close to the earthquake epicenter but can also affect those at great distances, particularly where thick clay-rich soils can amplify ground motions. Certain types of buildings are more vulnerable to ground shaking than others. Unreinforced masonry structures, tall structures without adequate lateral resistance, and poorly maintained structures are specifically susceptible to large earthquakes.

According to MoDNR's Missouri Geological Survey, damage from earthquakes in the New Madrid Seismic Zone will vary depending on the earthquake magnitude, the character of the land, and the degree of urbanization. The Bootheel area is dominantly rural with scattered small to medium-sized towns. Damage to the land could be extensive and significantly affect the area's farming industry. The more distant, densely populated urban area of St. Louis is not likely to have damage to the land, but its huge stock of structures and their contents could receive significant damage from shaking and earthquake-triggered landslides and sinkhole collapse. Shaking would be most severe to development built on thick, clay-rich soils. Roads and railroads in southeast Missouri and Saint Louis area could be severely damaged by earthquake triggered slope failures, rockfalls, and liquefaction.

During most earthquakes, liquefaction happens in relatively small, isolated patches. The New Madrid Seismic Zone is unique because it is in a vast area with ideal conditions for liquefaction. Liquefaction could be an enormous problem in a large earthquake and even for a magnitude 6–6.5 earthquake occurring in a portion of the Bootheel. Infrastructure (roads, bridges, power lines, gas lines, water lines, petroleum pipelines, telephone lines, ports, etc.) will be severely damaged and disrupted by liquefaction. This will make it difficult to perform rescue and recovery operations because these infrastructure facilities will be needed but will take a long time to repair.

Several studies indicate the need to prepare for earthquakes, as scholars estimate that the New Madrid Seismic Zone has the capability of generating Mercalli intensities of X (ten) in southeast Missouri. The late Dr. Otto Nuttli of St. Louis University stated in his book, *The Effects of Earthquakes in the Central United States*, that surface-wave magnitudes of 7.6 (Richter) would create the largest possible earthquake that could occur anywhere along the New Madrid Seismic Zone in the near future. Information on preparedness and predictions related to the New Madrid Seismic Zone is provided on the U.S. Geological Survey Earthquake Hazards Program web site at https://www.usgs.gov/mission-areas/natural-hazards, and the Center for Earthquake Research and Information web site at https://www.memphis.edu/ceri/seismic/.

Another report, *Impact of Earthquakes on the Central USA,* dated September 2008 presents the findings of a two-year study on the impact of a 7.7 magnitude earthquake on states in the New Madrid Seismic Zone (NMSZ). The study was conducted for FEMA by the Mid-America Earthquake (MAE) Center at the University of Illinois in partnership with the Central United States Earthquake Consortium (CUSEC), the U.S. Geological Survey (USGS), USACE, and George Washington University's Institute for Crisis, Disaster and Risk Management. It is primarily intended to provide scientific data upon which to base response and recovery planning for the devastating earthquakes that have long been predicted for the New Madrid region, which includes areas of Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri and Tennessee. The study is also available for download at https://www.ideals.illinois.edu/handle/2142/8971.

A 2019 report, *Where was the 31 October 1895 Charleston, Missouri, Earthquake?* revisits the magnitude and location of the historic earthquake in Charleston, Missouri, which is widely regarded to

be the most recent magnitude 6 or greater earthquake in the central United States. This study concludes that, within the Reelfoot Rift, elevated seismic hazard is not restricted to the New Madrid Seismic Zone (NMSZ) as conventionally defined, but continues into the Charleston region in southeastern Missouri where faults associated with the western edge of the Reelfoot Rift appear favorably oriented for failure in the current stress regime.

Earthquake Insurance Analysis

The Missouri Department of Commerce & Insurance, Statistics Section prepared a report in April 2022 on the state of earthquake coverage in Missouri. The report notes that earthquake coverage has become less available and less affordable with the following highlights:

- The cost of earthquake coverage has increased significantly, particularly in the high-risk New Madrid area. In just the last 10 years, costs have increased by 116 percent in the New Madrid counties. Since 2000, costs have increased by 816 percent.
- Insurers have increasingly pulled out of high-risk areas of the state or have subjected such areas to stricter underwriting standards.
- Policyholders are required to self-insure to a significant extent through higher deductibles and the application of separate deductibles to structure and contents. Some insurers will only sell policies with a deductible equal to 20 or 25% of policy limits.
- The market has contracted significantly over the last twenty years. In the six county New Madrid region of the state, the percentage of residences with earthquake coverage declined by an astonishing 49 percentage points between 2000 and 2021, from 60.2 to 11.4 percent.
- In 91 of Missouri's 115 counties, fewer than 20 percent of residences have earthquake coverage. Only in St. Charles County are at least half of residences insured from damage caused by earthquakes.
- Based on a survey of Missouri insurers, nearly 20 percent of the earthquake market in New Madrid do not offer coverage with a deductible of less than 25 percent of the value of the insured property. Less than 2 percent of the market offer policies with deductibles as low as five percent, compared to 41 percent of the earthquake market in the remainder of the state.

The full earthquake coverage report is included in **Appendix E.**

Overview and Analysis of Vulnerability

For the 2023 State Hazard Mitigation Plan, the vulnerability analysis combines and compares the efforts of FEMA's National Risk Index with state planning efforts. For State Hazard Mitigation Plan, Hazus software was used to analyze vulnerability and estimate losses to earthquakes for two scenarios:

- **Annualized Loss Scenario** - Hazus analyses were run using Level 1 building inventory database comprised of updated demographic and aggregated data based on the 2010 census. An annualized loss scenario that enabled an "apples to apples" comparison of earthquake risk for each county was synthesized from a FEMA nationwide annualized loss study (FEMA P-366 Hazus Estimated Annualized Earthquake Losses for the United States April 2017).

- **Probabilistic Loss Scenario** - An event with a 2% probability of exceedance in 50 years, was done to model a worst-case earthquake using a level of ground shaking recognized in earthquake-resistant design. The Central United States Earthquake Consortium provided state-wide National Earthquake Hazards Reduction Program (NEHRP) site classification and soil liquefaction characteristics. Furthermore, the Missouri Department of Natural Resources provided more detailed, quad-based NEHRP site classification and soil liquefaction characteristics for the areas surrounding the City of St. Louis. These data sets were used as additional, Level 2 data inputs to enhance the accuracy of earthquake hazard modeling. It should be noted that some of the National Earthquake Hazard Reduction Program (NEHRP) site classification attributes were slightly altered for incorporation into the Hazus platform. Areas that were classified as "C to D" were re-attributed as "D" since in these instances Hazus does not allow the data in its original format.

State Estimates of Potential Losses

Annualized Loss Scenario

The results of the updated annualized loss scenario are shown in **Figure 3.67**. The map shows direct economic losses to buildings annualized over eight earthquake return periods (100, 250, 500, 750, 1,000, 1,500, 2,000, and 2,500 years). Hazus defines annualized loss as the expected value of loss in any one year. The software develops annualized loss estimates by aggregating the losses and their exceedance probabilities from the eight return periods. Annualized loss is the maximum potential annual dollar loss resulting from various return periods averaged on a 'per year' basis. It is the summation of all HAZUS-supplied return periods multiplied by the return period probability (as a weighted calculation). This is the same scenario that FEMA National Risk Index uses to compare relative risk from earthquakes and other hazards at the county level nationwide. The trend shows dollar losses to be most significant in the southeastern portion of the State and in the urbanized areas near St. Louis. This is consistent with the southeastern portion of the State's proximity to the New Madrid Seismic Zone and the fact that the more developed areas in the region are likely to suffer the most building losses, particularly where there are large numbers of unreinforced masonry buildings.

The total annualized expected losses by county (including building and income losses) are presented in **Appendix A.** FEMA's National Risk Index also derives annualized losses from the FEMA P-366 study and presents the same annualized loss building data. The Risk Index calculates an annualized loss value for population as presented in **Figure 3.68**. This population equivalence is calculated using a Value of Statistical Life (VSL) approach in which each fatality or ten injuries is treated as $7.6 million of economic loss and adjusted for inflation for 2020 values. FEMA's National Risk Index combines the annualized losses for buildings and population for an overall expected annualized loss and loss rating. Figure

In addition to annualized loss, annualized loss ratios were calculated. The loss-ratio represents the ratio of the average annualized losses divided by the entire building inventory by county as calculated by Hazus. The loss ratio is an indication of the economic impacts an earthquake could have, and how difficult it could be for a particular community to recover from an event. The total annualized loss ratios by county are presented in **Appendix A.** FEMA's National Risk Index also calculates an historic loss ratio. This historic loss ratio represents the average rate of loss associated with an earthquake occurrence. Historical loss data was obtained from SHELDUS for 1960 through 2019. This included loss events for earthquakes, fires following earthquakes, landslides following earthquakes, and liquefaction events. The historic loss ratio computation also applies a spatial weighting matrix to smooth the loss ratio data

spatially to represent the hazard impacts more accurately across the state. For Missouri, this was calculated as a uniform value statewide of 0.01675. **Figure 3.70** presents historic loss ratios across the Nation.

Figure 3.67. Hazus Earthquake Loss Estimation: Annualized Loss Scenario—Direct Economic Losses to Buildings

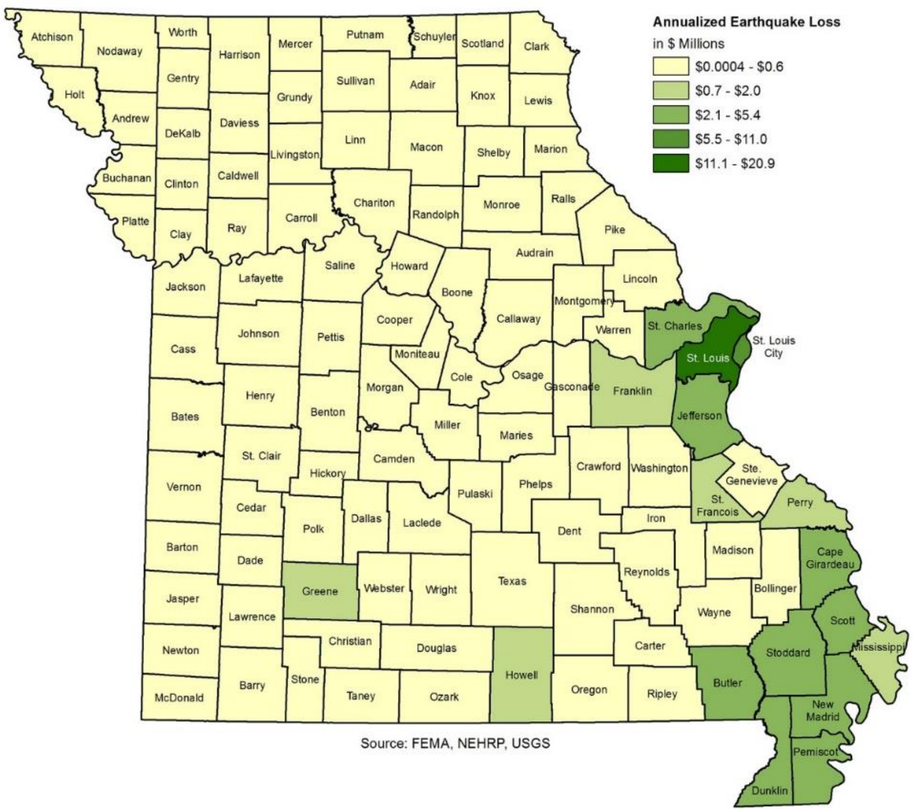


Figure 3.68. FEMA National Risk Index Annualized Loss Scenario—Population Equivalence

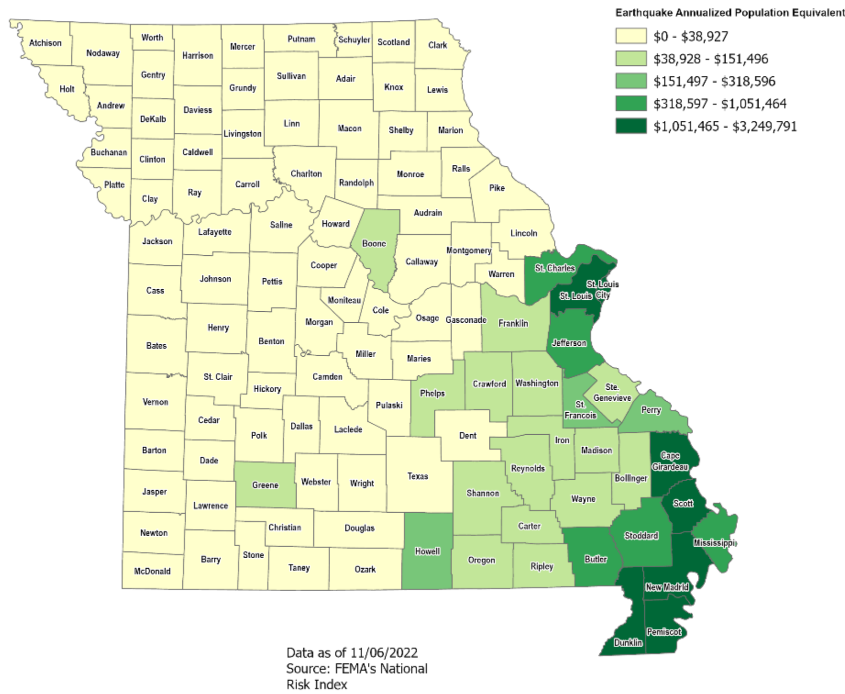


Figure 3.69. FEMA National Risk Index: Annualized Loss Rating

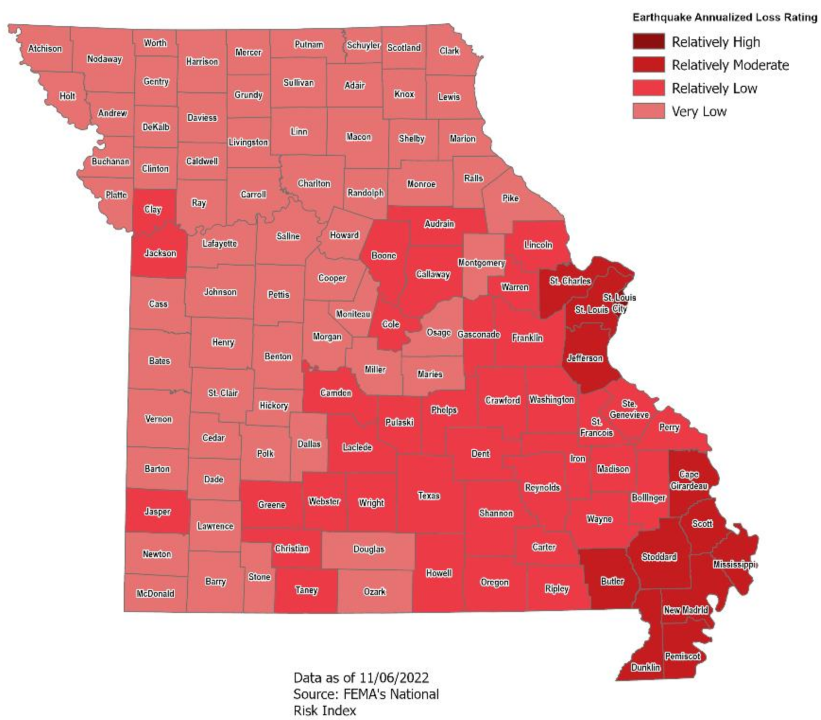
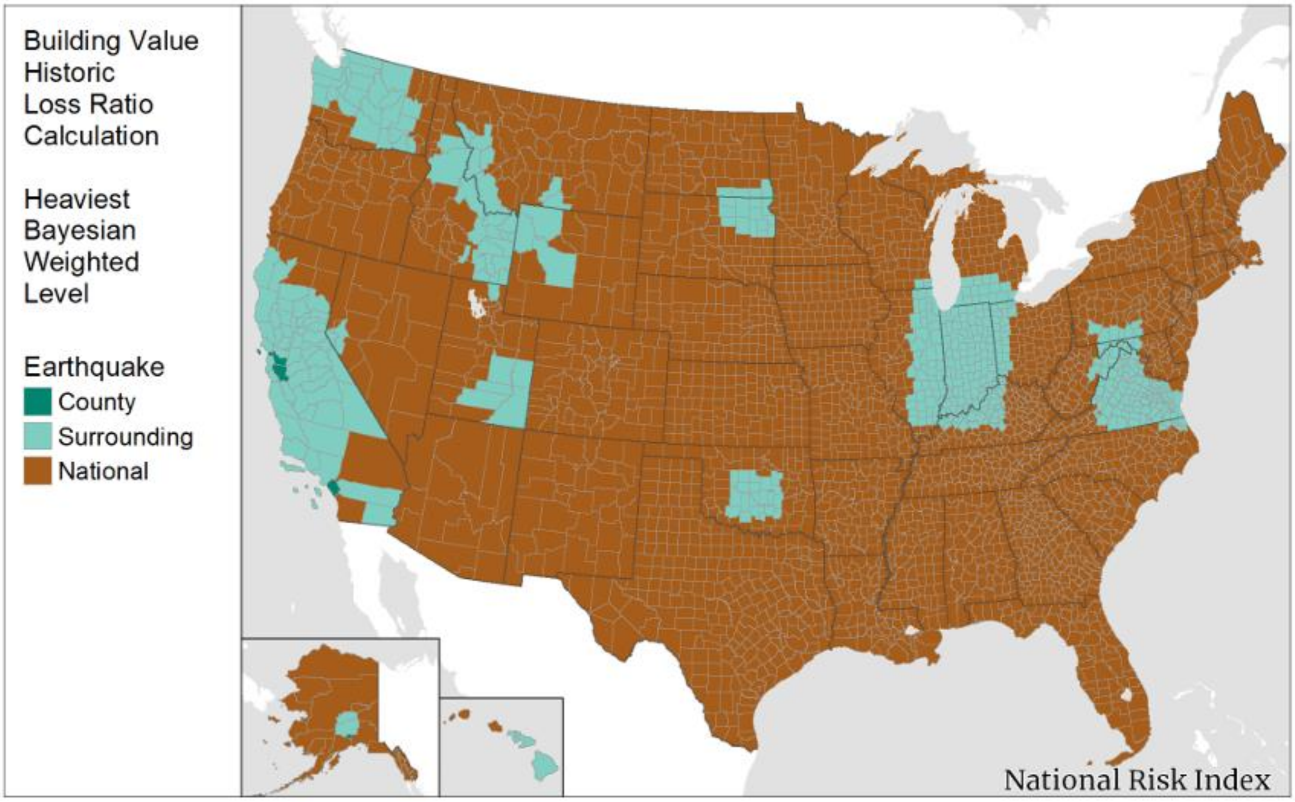


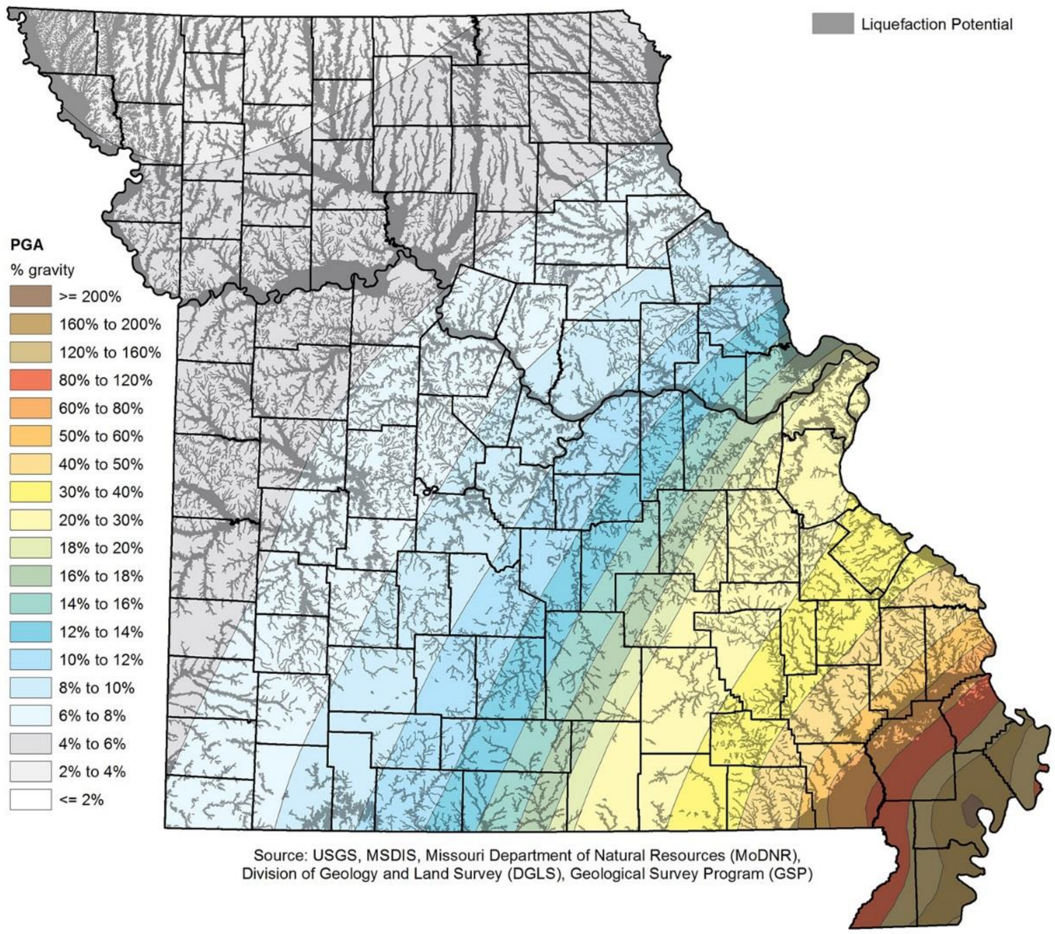
Figure 3.70. FEMA National Risk Index – Historic Loss Ratio



2% Probability of Exceedance in 50 Years Earthquake Scenario

A second scenario, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst-case scenario. This scenario is equivalent to the 2,500-year earthquake scenario in Hazus. The methodology is based on probabilistic seismic hazard shaking grids developed by the U.S. Geological Survey (USGS) for the National Seismic Hazard Maps that are included with Hazus. The USGS updated this mapping in 2014. The USGS maps provide estimates of peak ground acceleration and spectral acceleration at periods of 0.3 second and 1.0 second, respectively, which have a 2% probability of exceedance in the next 50 years. The International Building Code uses this level of ground shaking for building design in seismic areas. This scenario used a 7.7 driving magnitude in HAZUS-MH, which is the magnitude used for typical New Madrid fault planning scenarios in Missouri. While the 2% probability of exceedance in the next 50 years ground motion maps incorporate the shaking potential from all faults with earthquake potential in and around Missouri, the most severe shaking is predominately generated by the New Madrid Fault. This pattern of shaking can be seen in **Figure 3.71,** with corresponding potential for damage and areas with soils potentially susceptible to liquefaction.

Figure 3.71. Hazus Earthquake 2% Probability of Exceedance in 50 Years —Ground Shaking and Liquefaction Potential



Scenario Results

The results of this probabilistic scenario include total losses exceeding $51.4 billion in building and income losses, with overall economic losses exceeding $63 billion. **Table 3.48** summarizes the building related losses by county. Hazus estimates direct damage to structural and non-structural building components separately. Structural components are the walls, columns, beams and flood systems that are responsible for holding up the building. In other words, the structural components are the gravity and lateral load resisting systems. Non-structural building components include building mechanical/electrical systems and architectural components such as partition walls, ceilings, windows and exterior cladding that are not designed as part of the building load carrying system. Equipment that is not an integral part of the building, such as computers, is considered building contents.

Damage to structural components affects other losses differently than damage to non-structural components. For example, if the ceiling tiles fall down in a building, business operations can probably resume once the debris is removed. On the other hand, if a column in a building is damaged, there is a life safety hazard until the column is repaired or temporarily shored, possibly resulting in a long-term disruption. Summary of building damage counts by occupancy class and county for the 2% probability of exceedance in 50 years scenario are shown in.

Table 3.48. Hazus Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Results – Summary of Overall Impacts in Missouri

Type of Impact	Summary of Modeled Impacts
Total Buildings Damaged	Slight: 372,790 Moderate: 223,225 Extensive: 88,883 Complete: 47,549
Building and Income Related Losses	$51.4 billion
Total Economic Losses (includes building, income and lifeline losses)	$63.4 billion
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 15,454 Requiring hospitalization: 3,855 Life threatening: 512 Fatalities: 999
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 21,732 Requiring hospitalization: 5,727 Life threatening: 833 Fatalities: 1,606
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 15,480 Requiring hospitalization: 4,020 Life threatening: 574 Fatalities: 1,090
Damage to Schools	339 with at least moderate damage*
Damage to Medical Facilities	159 with at least moderate damage*
Damage to Fire Stations	194 with at least moderate damage*
Damage to Transportation Systems	819 highway bridges, at least moderate damage* 464 highway bridges, complete damage* 4 railroad bridges, moderate damage 12 airport facilities, moderate damage
Households without Power/Water Service (based on 2,375,611 households)	Power loss, Day 1: 364,335 Water loss, Day 1: 753,546 Water loss, Day 3: 730,857 Water loss, Day 7: 687,407 Water loss, Day 30: 549,352 Water loss, Day 90: 254,958
Displaced Households	48,730
Shelter Requirements	32,237 people out of 5,988,927 total population
Debris Generation	16.2 million tons

Table 3.49. Hazus Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Results – Summary of by Occupancy Class (Millions of Dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses	Wage	$0.00	$137.35	$1,494.55	$82.36	$119.30	$1,833.52
	Capital-Related	$0.00	$58.59	$1,217.03	$50.99	$30.64	$1,357.23
	Rental	$610.67	$425.50	$666.99	$30.81	$55.85	$1,789.81
	Relocation	$2,089.36	$380.76	$1,107.27	$147.23	$460.23	$4,184.85
	Subtotal	**$2,700.03**	**$1,002.20**	**$4,485.84**	**$311.39**	**$666.02**	**$9,165.41**

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Capital Stock Losses	Structural	$3,581.98	$879.63	$2,018.83	$573.42	$605.33	$7,659.20
	Non-Structural	$12,295.72	$3,928.15	$5,230.69	$1,737.85	$1,559.66	$24,752.07
	Content	$3,915.69	$1,007.10	$2,641.24	$1,170.28	$799.40	$9,533.72
	Inventory	$0.00	$0.00	$72.52	$199.57	$15.57	$287.66
	Subtotal	**$19,793.39**	**$5,814.88**	**$9,963.28**	**$3,681.12**	**$2,979.96**	**$42,232.65**
	Total	**$22,493.42**	**$6,817.08**	**$14,449.12**	**$3,992.51**	**$3,645.98**	**$51,398.06**

Figure 3.72 depicts a map of the modeled earthquake impacts by county based on building losses, including structural and nonstructural damage, content and inventory loss, and wage and income loss. **Figure 3.73** depicts loss ratio by county, which is the ratio of the building structure and nonstructural damage to the value of the entire building inventory. The loss ratio is a measure of the disaster impact to community sustainability, which is generally considered at risk when losses exceed 10 percent of the built environment (FEMA). The loss-ratio map depicts considerable losses in southeastern Missouri, which is consistent with being in close proximity to the New Madrid Seismic Zone and high liquefaction potential.

See **Appendix A** for the total building losses by county.

FEMA's National Risk Index has developed an overall risk rating for earthquakes which combines the expected annual loss with social vulnerability and community resilience. Social vulnerability is determined from the University of South Carolina's social vulnerability index. Community resilience is determined from the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) Baseline Resilience Indicators for Communities. The overall risk rating for Missouri Counties is presented in **Figure 3.74**.

Figure 3.72. Hazus Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Total Building Loss

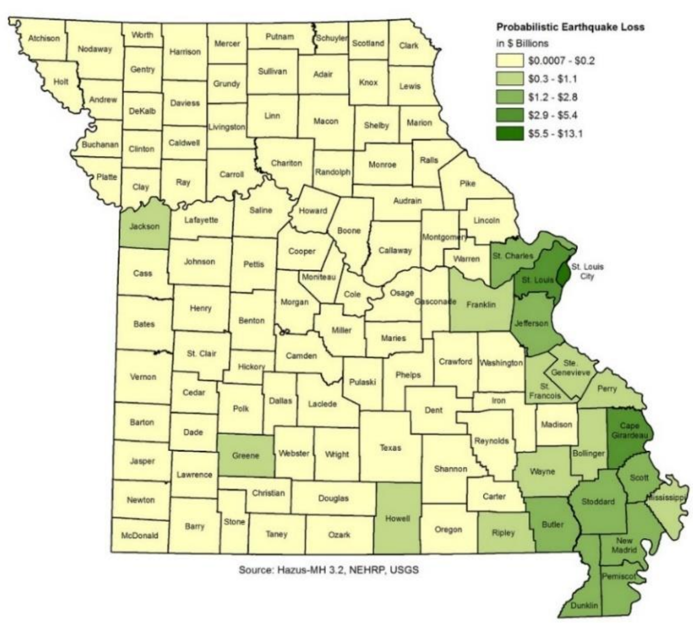


Figure 3.73. Hazus Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Loss Ratio

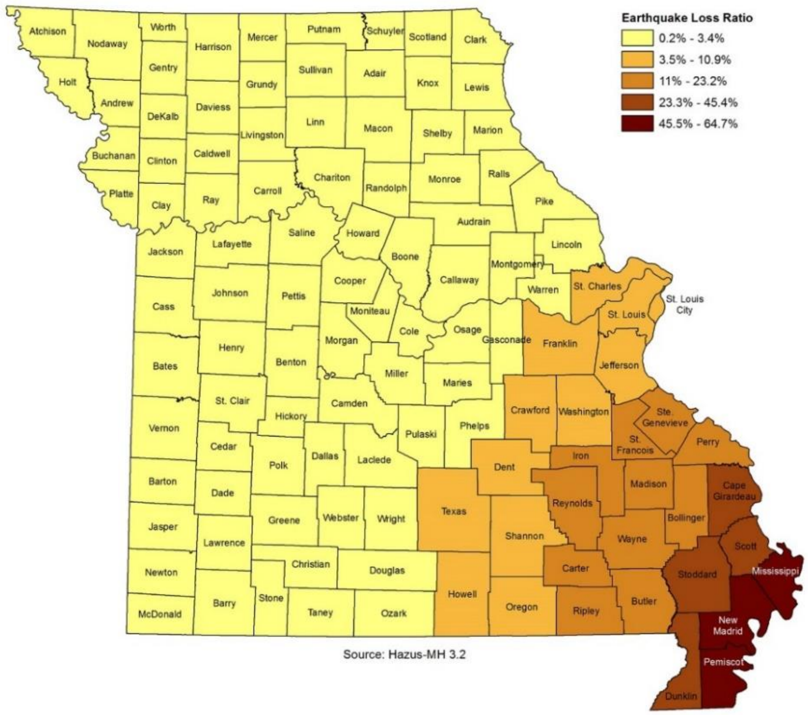
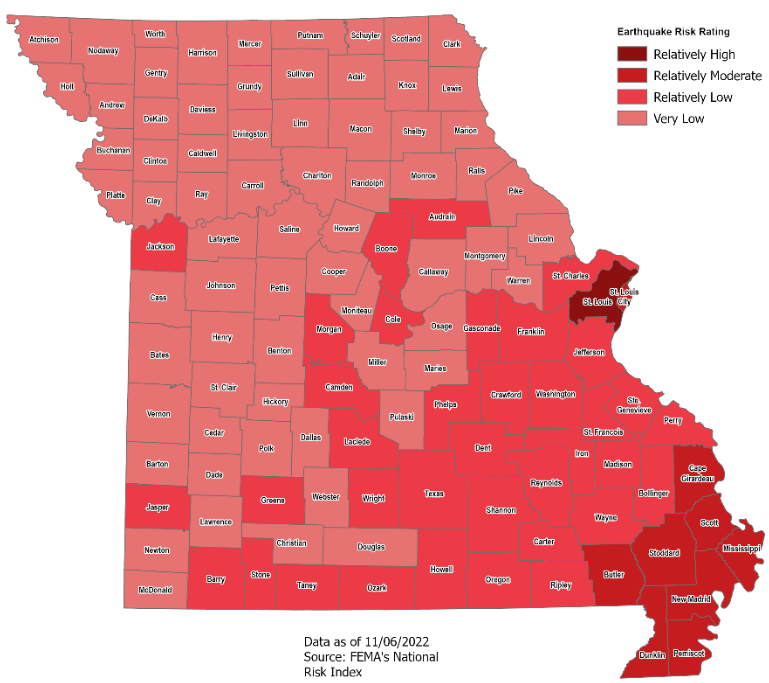


Figure 3.74. FEMA's National Risk Index – Earthquake Risk Rating



Hazard Impact on Future Growth and Development

According to the population trends analysis, there is generally not significant development and growth occurring in high vulnerable areas. The exception to this is Cape Girardeau County which experienced 6.6% population growth between 2010 and 2015. To some extent modern building codes will help to reduce damage and casualties associated with future structures from earthquakes. Future state facilities in the high-risk areas of southeast Missouri should be built to account for potential earth shaking and earthquake impacts.

Risk Summary

The exact timing is unknown, but the State is overdue for a damaging earthquake. The New Madrid Seismic Zone is considered as seismically active as some areas of California and has been the source of some of the strongest earthquakes felt anywhere in the country. Based on FEMA's National Risk Index, hazus modeling, and historic incidents the earthquake could have significant impacts on the citizens of Missouri, particularly in the southeastern and eastern parts of the state and surrounding states. Earthquakes also have secondary effects such as soil liquefaction, fires, building collapse, transportation infrastructure damage, utility disruptions, dam failures, flooding, hazardous material releases, environmental impacts, and long-term economic disruptions or losses.

Problem Statement:

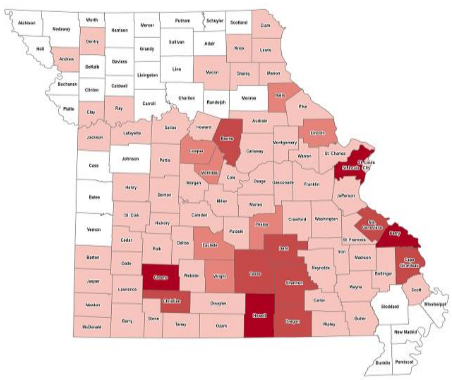
Using the loss ratio for the 2% probability of exceedance in 50 years as the key indicator, the data suggests that it would most feasible to concentrate mitigation efforts and dollars first in Mississippi, New Madrid and Pemiscot. Following next would be concentration of resources on Cape Girardeau, Dunklin, Scott, and Stoddard Counties with a general focus of remaining resources in the remaining southeast area of the State. This follows the risk ratings from FEMA's National Risk Index with the addition of Butler and St. Louis Counties and the City of St. Louis.

2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.5. Land Subsidence/Sinkholes

Description

Land subsidence is a geological hazard caused by the sinking of the earth's surface due to the movement of earth materials below the surface. This sinking can be sudden or gradual and is generally attributed to the removal of subsurface water or the draining of organic soils. In Missouri, subsidence is primarily associated with sinkholes, but they can also occur from void space left by mining and natural caves.

Vulnerability	Extent/Range of Intensity
	There is no scale for measuring or determining the severity of sinkholes. However, geological and mining parameters can affect the magnitude and extent of sinkhole subsidence. Natural sinkholes develop in areas where the rock below the surface is limestone, carbonate rock, salt beds or any type of rock that can naturally be dissolved by groundwater circulating through it. Artificial sinkholes develop due to groundwater pumping, water main and sewer collapses, and mine collapses.

Probability	Severity	Location
83%	Low	Predominately southern portion of State

Location

St. Louis City and St. Louis County, Greene, Christian, St. Charles, Perry and Ste. Genevieve

State Vulnerability Overview

Sinkholes vary in size and location. These factors will determine the impact of the hazard, which could manifest as the loss of a personal vehicle, a building collapse or damage to infrastructure such as roads, water or sewer lines. Because of the relationship of sinkholes to groundwater, pollutants captured in sinkholes (or dumped) can affect a community's groundwater system. Sinkhole collapse could be triggered by large earthquakes, which could be particularly problematic for the St. Louis metropolitan area. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

Changing Future Conditions Considerations

Direct effects from changing climate conditions such as an increase in droughts and could contribute to an increase in sinkholes. These changes raise the likelihood of torrential rain and flooding conditions which often lead to the exposure of sinkholes. Certain events such as a heavy precipitation following a period of drought can trigger a sinkhole due to low levels of groundwater combined with a heavy influx of rain.

Risk Summary/Problem Statement

Often, the geographical extent of this hazard is known, as such mitigation can be targeted. Avoiding the hazard is much more cost effective than altering or mitigating the sinkhole itself. Mitigation efforts and dollars focused on counties listed above would be most feasible.

Description/Location

Land subsidence is a geological hazard caused by the sinking of the earth's surface due to the movement of earth materials below the surface. This sinking can be sudden or gradual and is generally attributed to the removal of subsurface water or the draining of organic soils. In Missouri, subsidence is primarily associated with sinkholes, but they can also occur from void space left by mining and natural caves.

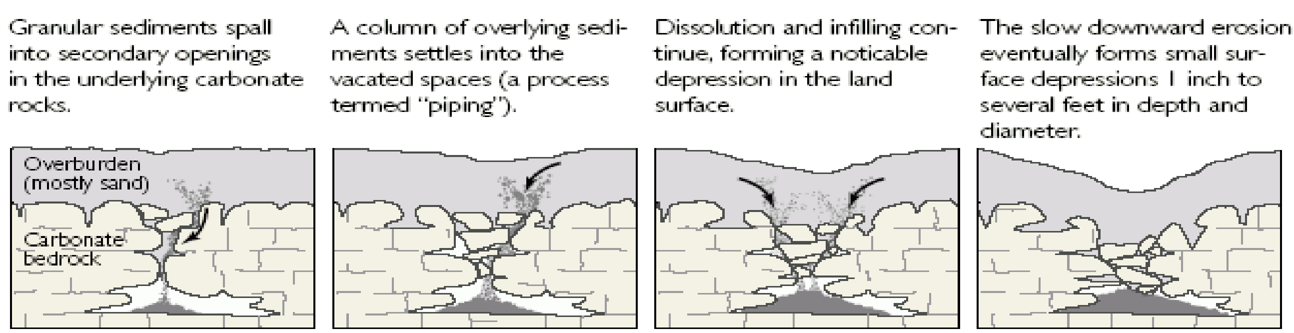
Sinkholes

Sinkholes can be natural or artificial and can develop in several different ways and vary in size and shape. Natural sinkholes develop in areas where the rock below the surface is limestone, carbonate rock (as found in Missouri), salt beds or any type of rock that can naturally be dissolved by groundwater circulating through it. This process of the dissolution of rock is known as the karst process. As the rock dissolves, spaces and caverns develop which potentially lead to sinkholes forming above these voids. Natural sinkholes can vary from a few square feet in area to hundreds of acres and can be from one foot deep to hundreds of feet deep. Naturally occurring sinkholes are typically permanent and have flood risk associated with them which need to be assessed.

Artificial sinkholes are created by man-made events. Examples of artificial sinkholes include groundwater pumping, water main and sewer collapses and even mine collapses. Artificial sinkholes can also be linked to land-use and development practices. Unlike natural sinkholes, artificial sinkholes typically are not permanent and do not have flood risk associated with them. In most cases, if an artificial sinkhole is created, the issues causing the sinkhole are dealt with and the sinkhole filled in.

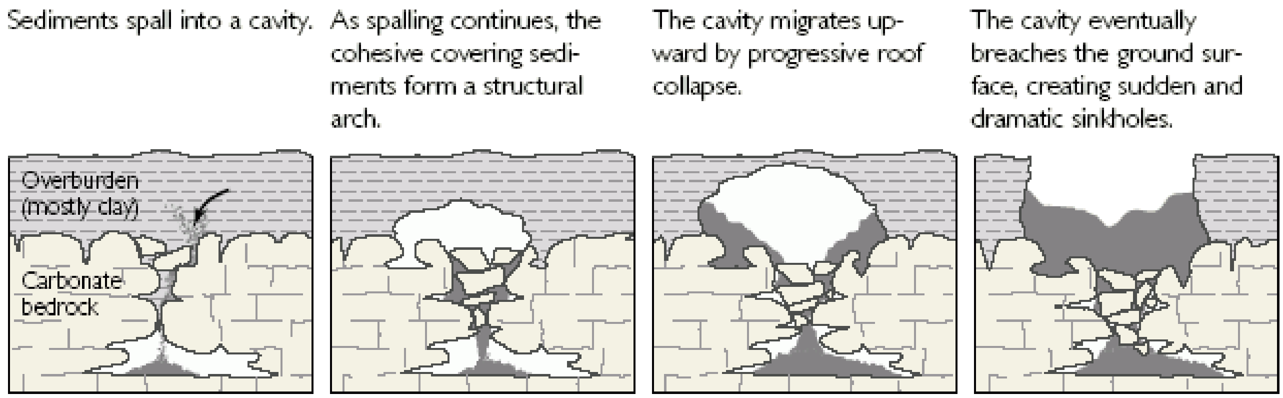
There are two ways that a naturally occurring sinkhole is formed, by cover-subsidence or by cover-collapse. Cover subsidence is a relatively slow process as observed from the surface. The overlying earth above an underground void slowly settles and fills the void. This process can go undetected for long periods and can be hard to detect in rolling terrain. Cover collapse occurs much more rapidly; this is where the earth above a void cannot support itself any longer and collapses into the void. Both processes are depicted in **Figure 3.75** and **Figure 3.76.**

Figure 3.75. Depiction of the cover-subsidence process



Source: water.usgs.gov

Figure 3.76. Depiction of the cover-collapse process

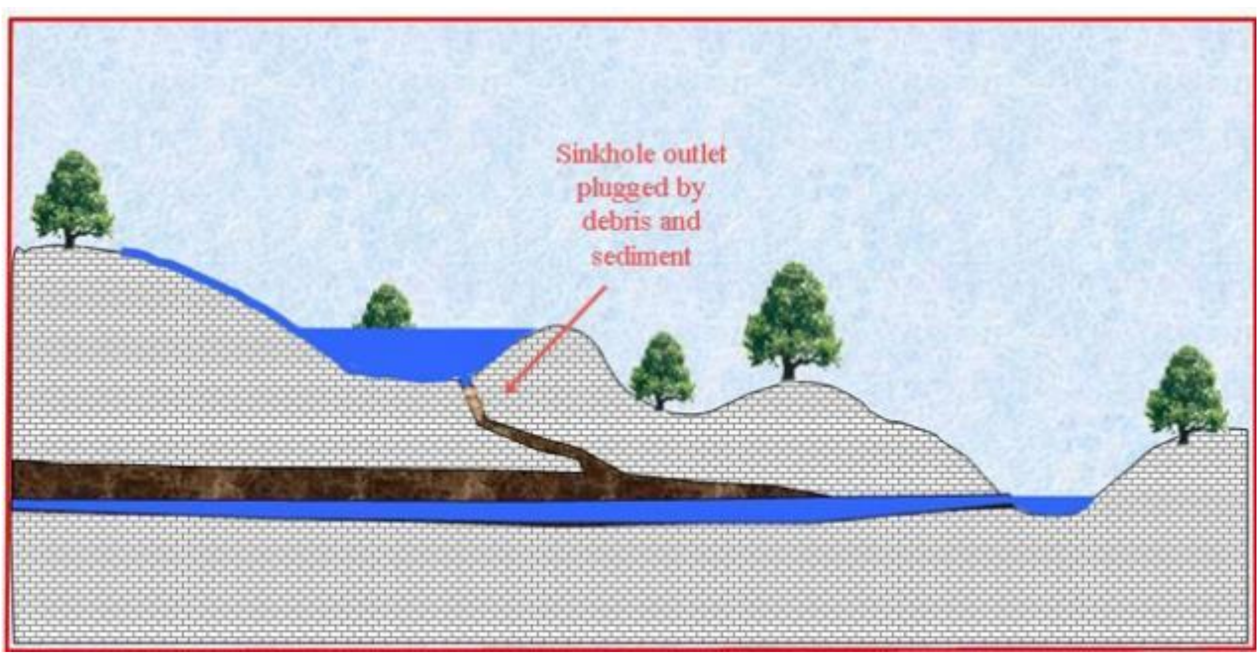


Source: water.usgs.gov

Once formed, there are four main ways sinkholes can subsequently fill with water and cause a flooding hazard. Two flood situations are created when the rate of run-off water flowing into the sink is greater than the rate of flow out of the sink. These are caused by either (1) a plugged throat; or (2) an insufficient outlet size. The other two flood situations are caused by the reversal of groundwater flow when backwater backs up into the sink from underground. These two are caused by either (1) backwater from a river; or (2) from another sinkhole.

Flooding in a sinkhole can occur when the throat or the outlet of the sinkhole is plugged with debris and cannot drain the sinkhole at the rate run-off is filling the sinkhole. This flooding can be seen in **Figure 3.77** below.

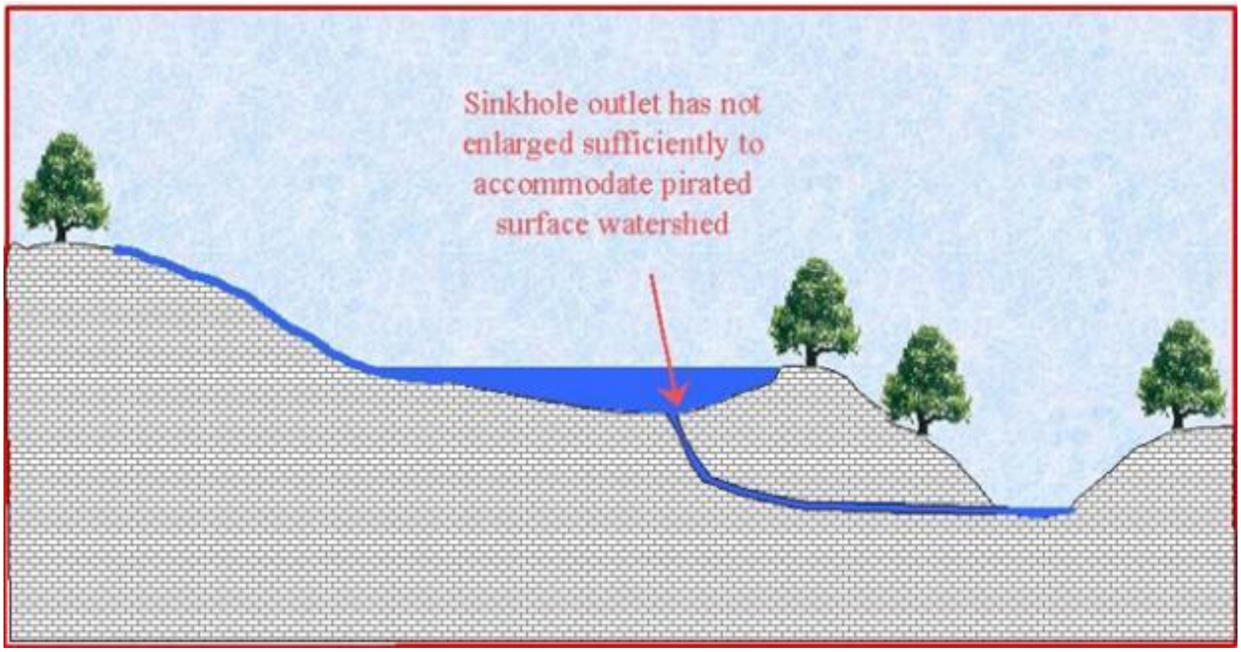
Figure 3.77. Flooding Caused by Plugged Throat



Source: www.uky.edu

Flooding in a sinkhole can occur when the throat or the outlet of the sinkhole is not large enough to drain the sinkhole at the rate run-off is filling the sinkhole. This flooding can be seen in **Figure 3.78** below.

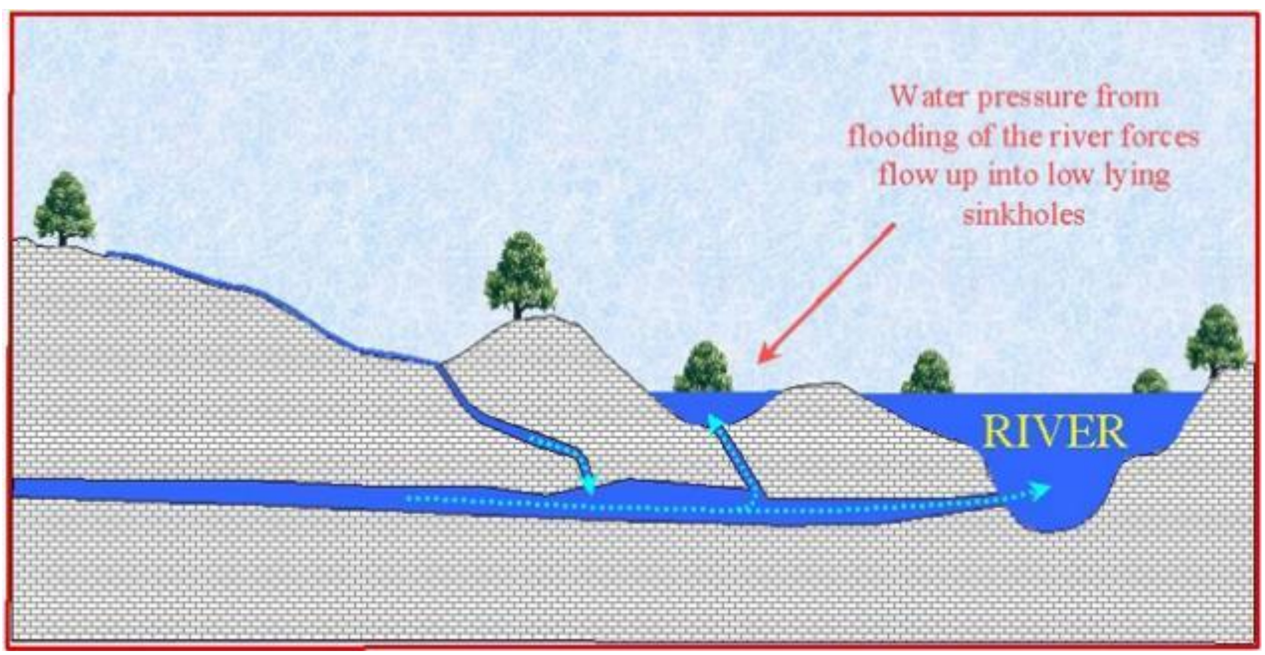
Figure 3.78. Flooding Caused by Plugged Throat



Source: www.uky.edu

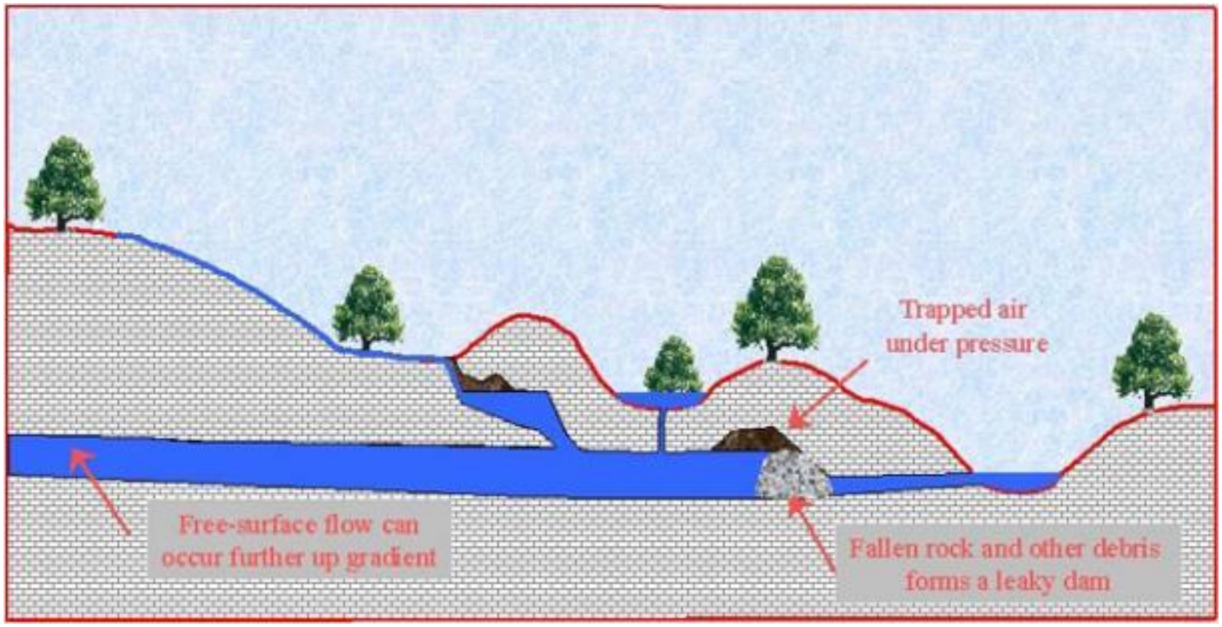
Flooding in a sinkhole can occur when there is flooding on a nearby stream or river which causes water to back up under ground and fill the sink hole by reversing the flow of water through its throat. This flooding can be seen in **Figure 3.79** below.

Figure 3.79. Flooding Caused by Riverine Backwater



Flooding in a sinkhole can occur when there is flooding in a nearby sinkhole which cannot drain fast enough to a river which ultimately causes water to back up under ground and fill the sink hole by reversing the flow of water through its throat. This flooding can be seen in **Figure 3.80** below.

Figure 3.80. Flooding Caused by Sinkhole Backwater



Source: www.uky.edu

There are many ways to locate sinkholes varying from observation to computer processing. Communities may have their own inventory of sinkholes which have been documented over time based on observation. The MoDRN's Missouri Geological Survey has created a statewide inventory of sinkholes which documents approximately 16,000 larger more well-known sinkholes. Whereas, Greene County has developed its own inventory of sinkholes which documents more than 7,500 sinks in Greene County alone. The largest known sinkhole is approximately 700 acres in western Boone County southeast of where I-70 crosses the Missouri River.

Mining

Mining activity in Missouri has been occurring since the early 1740s. Missouri has a vast amount of minerals hidden beneath the surface. Minerals founds include lead, vast supplies of zinc, copper, nickel, and cobalt, tripoli, stone, clay, industrial sand, lime, barite, and coal were extracted from Missouri's mines.

Natural Caves

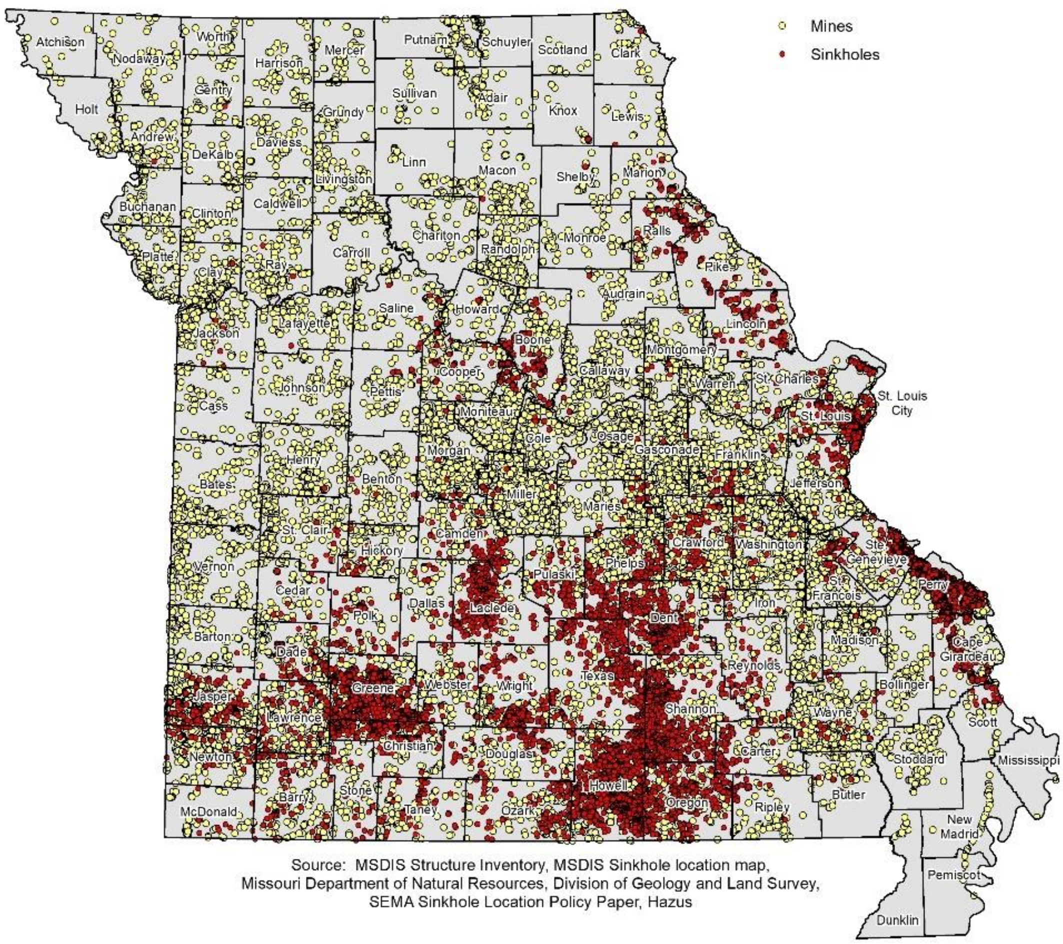
A cave is a natural underground opening large enough to explore, therefore, a cave may be a rock shelter, or a pit opening in the bottom of a sinkhole, or a cavernous, many-roomed passage that extends deep into the earth. Missouri is known for their more than 6,300 natural caves through the State.

Location

According to the U.S. Geological Survey, the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Fifty-nine percent of Missouri is

underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes. Sinkholes occur in Missouri on a frequent basis. Most of Missouri's sinkholes occur naturally in the State's karst regions (areas with soluble bedrock). They are a common geologic hazard in southern Missouri, but also occur in the central and northeastern parts of the State. **Figure 3.81** through **Figure 3.85** present the location of sinkholes, mines, and caves across the State.

Figure 3.81. Location of Sinkholes and Mines



Source: MSDIS Structure Inventory, MSDIS Sinkhole location map, Missouri Department of Natural Resources, Division of Geology and Land Survey, SEMA Sinkhole Location Policy Paper, Hazus

Figure 3.82. Cave Density

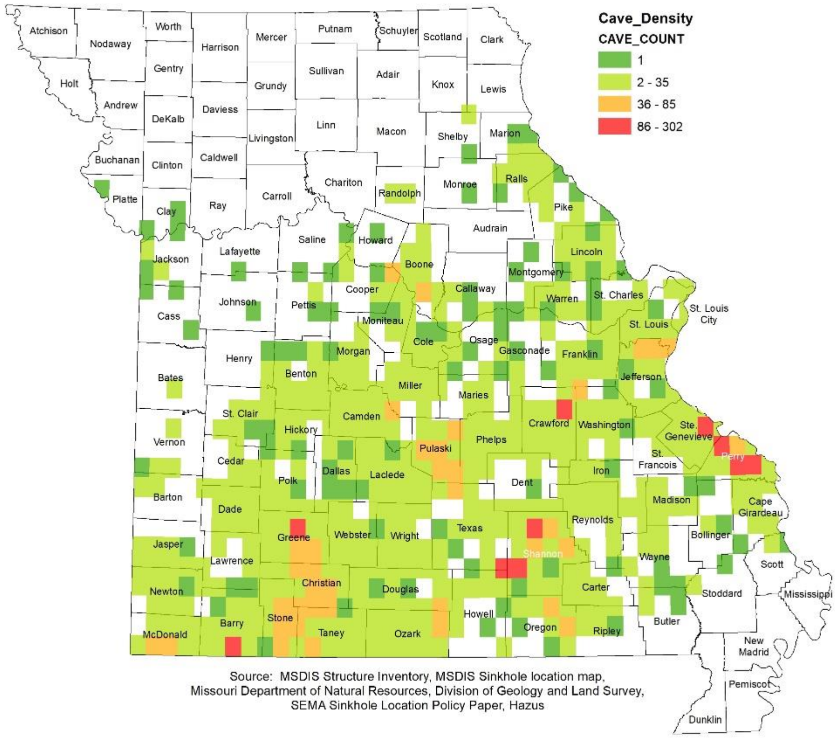


Figure 3.83. Sinkhole Counts per County

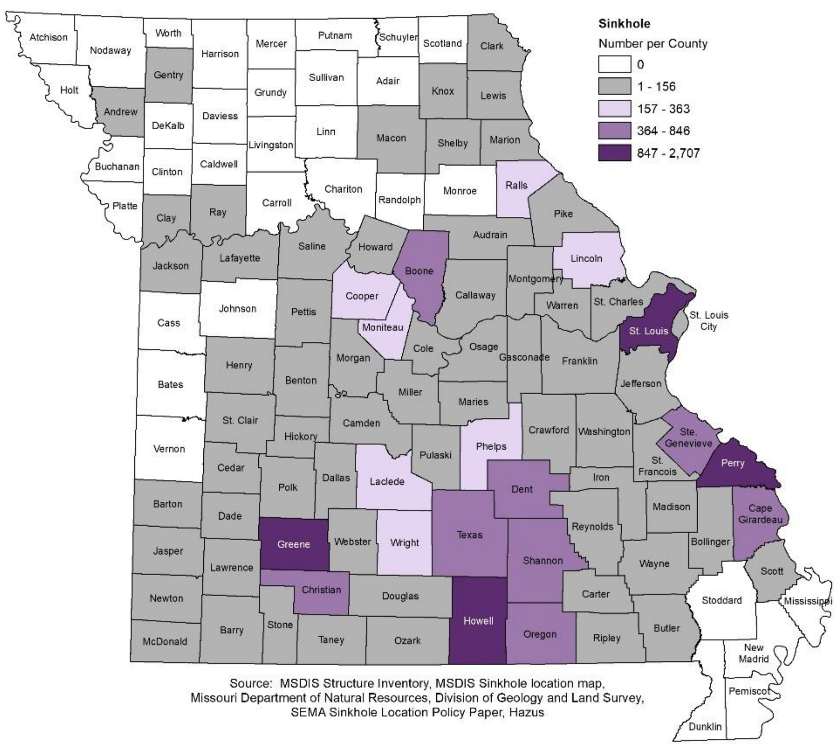


Figure 3.84. Mine Counts per County

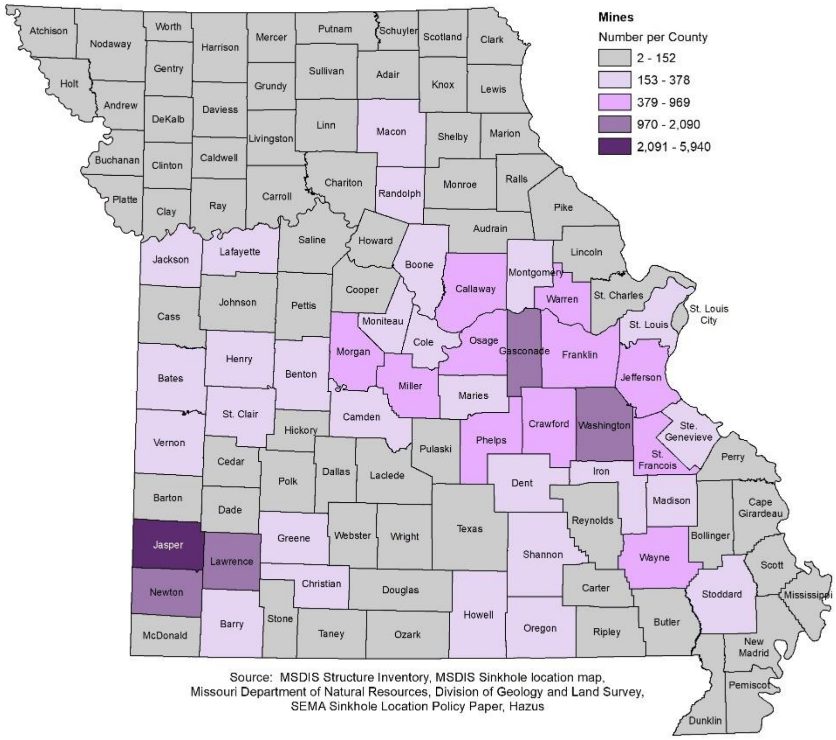
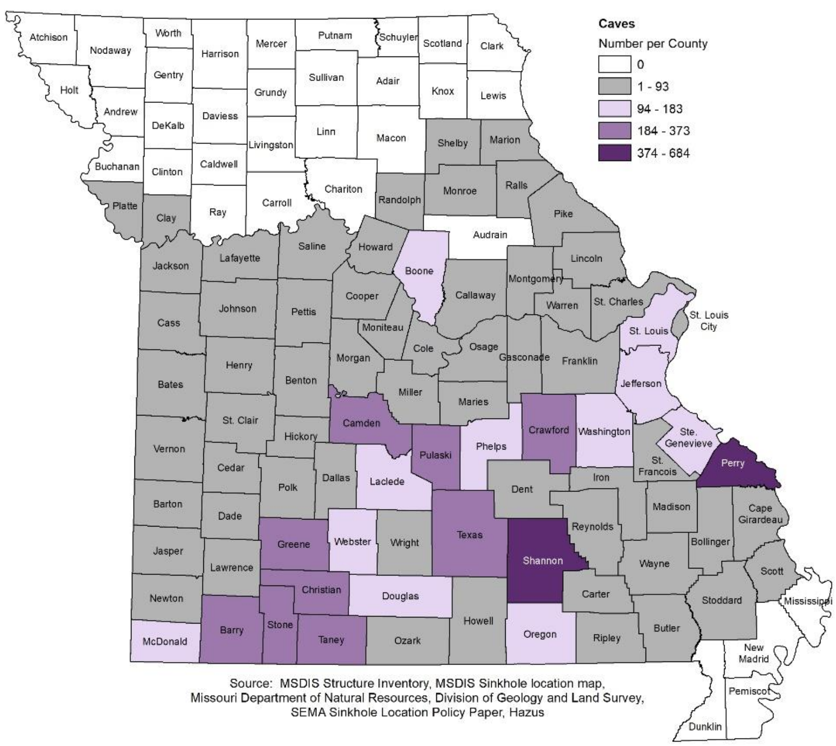


Figure 3.85. Cave Counts per County



Extent/Range of Intensity

Unlike earthquakes or other geologic hazards, there currently is no scale for measuring or determining the severity of sinkholes. However, geological and mining parameters can affect the magnitude and extent of sinkhole subsidence. As previously noted, natural sinkholes develop in areas where the rock below the surface is limestone, carbonate rock (as found in Missouri), salt beds or any type of rock that can naturally be dissolved by groundwater circulating through it. Artificial sinkholes develop due to groundwater pumping, water main and sewer collapses, and mine collapses.

Previous Occurrences

Sinkholes are a regular occurrence in Missouri, but rarely are the events of any significance. However, there have been occasional damages related to sinkholes. The following events are from Jim Vandike's "That Sinking Feeling—A Void, a Collapse" in the Spring/Summer 2003 issue of Missouri's Department of Natural Resources' Missouri Resources:

In 1948, a well-drilling rig was constructing a mineral-test hole on the St. Francis River floodplain in St. Francois County when sinkholes began developing around the rig. By the time the well was cased, there were approximately 20 sinkholes up to 90 feet long and 20 feet wide within 500 feet of the rig.

A lake in northern Howell County was built in the 1960s on a tributary of the Eleven Point River in an area characterized by deeply weathered bedrock, losing streams, and sinkholes. A sinkhole formed in the floor of the lake and quickly drained it. Efforts to stop the leak failed and the lake will only hold water for short periods following heavy rainfall.

Sinkhole collapses have occurred in sewage lagoons at several southern Missouri towns including West Plains and Republic. In most instances, the lagoons were abandoned, and new lagoons were constructed on better sites or the towns switched wastewater-treatment methods.

Mining-related collapses have occurred in the Joplin area where lead and zinc were once mined; southeastern Missouri (Washington, Iron, St. Francois, and Reynolds Counties), where lead has been mined since the 1700s; northern and western Missouri (and part of St. Louis) where coal was mined underground prior to the 1940s; and throughout Missouri where underground limestone quarries are common.

Other notable events include the following:

- In May 2021, much of a 17-acre lake in Missouri disappeared after a sinkhole materialized.
- In May 2017, Missouri State Highway Patrol spotted a newly formed giant sinkhole near West Plains, Missouri which was swallowing the recent floodwaters.
- In April 2016, a garbage truck fell into sinkhole while picking up trash on its route in Boone County and a dump truck fell into a sinkhole suddenly along in Clayton, Missouri near Central Avenue and Maryland Avenue.
- In March 2016, a U.S. Marine at Fort Leonard Wood died while hunting in south central Missouri after falling into an unseen sinkhole in Pulaski County.
- In May 2015, a sinkhole was discovered near the entrance to Top of the Rock golf course in Branson Missouri that was 80 feet wide and 35 feet deep. Nearly 7,000 cubic feet of material was displaced by the hole which has since been filled in.

- In April 2014, sinkholes in Reynolds County appeared near the West Fork mine at the Doe Run lead mining facility. A sinkhole more than 100 feet wide opened near the historic West Fork Sutterfield Cemetery. It is possible that mining operations may have been linked to this event.
- In August 2013, City of Springfield Utility crews discovered a 50-foot wide 25 foot deep sinkhole near Walnut Lawn at Cox while installing water mains.
- In June 2013, sinkhole damage caused road closures on south Sprigg Street at La Cruz Street. One sinkhole was about 15 feet deep and the other was about 8 feet deep.
- In January 2013, the owner of a used car company in Sugar Creek, Missouri experienced damage from a sinkhole appearing in the parking lot.
- August 6, 2012, a sinkhole caused a road to collapse near Springfield-Branson National Airport. A water main snapped when the concrete collapsed. The hole likely formed after heavy rains.
- In July 2010, MODOT had to close a section of I-470 in Kansas City because of damage from a sinkhole at the Three Trails Crossing intersection.
- In 2009 a sinkhole approximately 70' by 30' at the bottom of a rain runoff area in Battlefield, Greene County, had to be patched as it threatened a city sewer lift station. (News-Leader, 2009)
- In August 2006, a sinkhole collapse in the City of Nixa in Christian County severely destroyed a residence and vehicle and threatened adjacent homes and city utilities. No one was injured in this event.
- In February 2005, a sinkhole appeared in a pasture in Barry County and grew to be the size of a football field.
- In June 2004, a sinkhole drained 23-acre Lake Chesterfield in St. Louis County.

Figure 3.86. Sinkhole Example from the St. Louis County, Lone Elk Park, May 2021

Source: https://www.audacy.com/kmox/news/local/st-louis-county-agonizes-over-lone-elk-park-sinkhole-choice

Probability of Future Hazard Events

Since 2004, 15 notable sinkhole events have occurred within the State. Historically sinkholes occur in areas away from development and typically do not cause serious damage. The probability of future events is at least 83%.

Changing Future Conditions Considerations

Direct effects from changing climate conditions such as an increase in droughts and could contribute to an increase in sinkholes. These changes raise the likelihood of extreme weather, meaning the torrential rain and flooding conditions which often lead to the exposure of sinkholes are likely to become increasingly common. Certain events such as a heavy precipitation following a period of drought can trigger a sinkhole due to low levels of groundwater combined with a heavy influx of rain.

State Vulnerability Overview

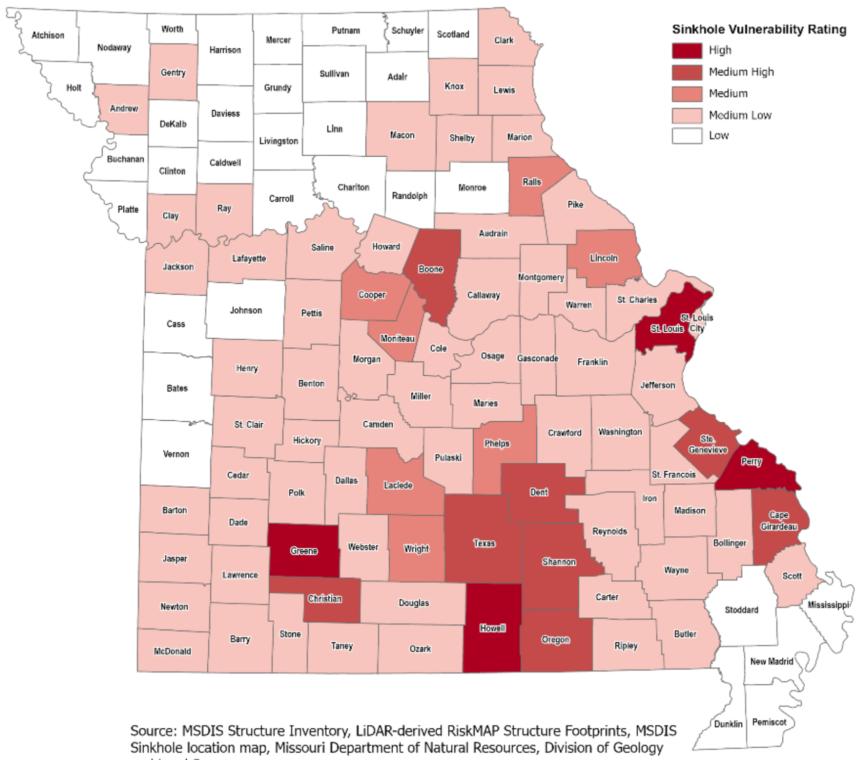
Sinkholes vary in size and location. These factors will determine the impact of the hazard, which could manifest as the loss of a personal vehicle, a building collapse or damage to infrastructure such as roads, water or sewer lines. Groundwater contamination is also a possible impact of a sinkhole. Because of the relationship of sinkholes to groundwater, pollutants captured in sinkholes (or dumped) can affect a community's groundwater system. Sinkhole collapse could be triggered by large earthquakes, which could be particularly problematic for the St. Louis metropolitan area. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

A statewide sinkhole inventory has been created by MoDNR's Missouri Geological Survey that will be used in addition to new data being developed for some newly mapped floodplain areas. The new data is being developed using the methods outlined in the Missouri Sinkhole Analysis Policy paper "Analysis and Communication of Flood Risk for Sinkholes in Missouri" funded in 2016 by SEMA. These inventories are polygon features which will be used for count analysis within ArcGIS.

The sinkhole hazard layer was used in conjunction with the MSDIS structure file and LiDAR-derived RiskMAP structure footprints to determine structures that fall within sinkhole areas as well as structures that are within a buffered distance of 50 feet of sinkholes. Based on natural breaks in the data, a rating value of 5 categories from low to high was assigned.

All county-level statistical data tables, including ranges for vulnerability factor ratings, are presented in Appendix A. **Figure 3.87** presents the vulnerability summary for sinkhole subsidence events.

Figure 3.87. Sinkhole Rating Value by County



Source: MSDIS Structure Inventory, LiDAR-derived RiskMAP Structure Footprints, MSDIS Sinkhole location map, Missouri Department of Natural Resources, Division of Geology and Land Survey

State Estimates of Potential Losses

From the GIS data collected and analysis performed, **Figure 3.88** shows the potential for losses due to sinkholes while **Figure 3.89** shows the population potentially impacted by sinkholes. All county-level statistical data tables are presented in **Appendix A**.

Figure 3.88. Ranking of Structures Potentially Impacted by Sinkholes by County

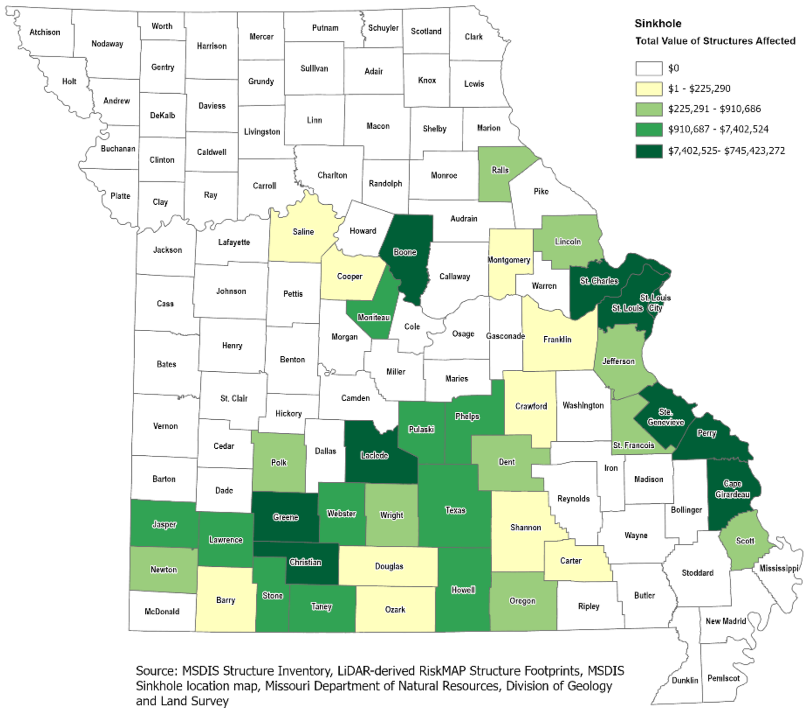
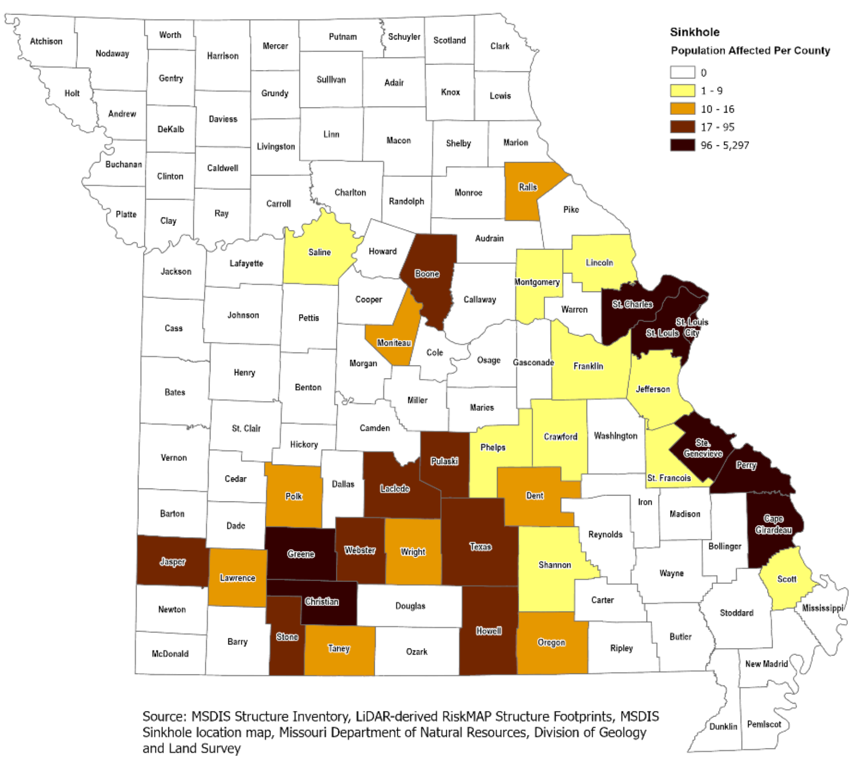


Figure 3.89. Ranking of Population Potentially Impacted by Sinkholes by County



Hazard Impact on Future Growth and Development

St. Louis, Greene, Perry, Christian, St. Charles, Ste. Genevieve, and Cape Girardeau Counties and the City of St. Louis all had potential population impacts to over 100 persons. St. Louis, Greene, Perry, Christian, and St. Charles Counties and the City of St. Louis also had potential building impacts to over 100 structures.

St. Louis, Greene, Christian, and St. Charles Counties were among the top 10 counties with greatest housing unit gains between 2010 and 2019. Greene, Christian, and St. Charles were also among the top 10 counties with the greatest population gains between 2010 and 2019. With growing population and increased development, this is some potential for increased losses as a result of the increase in exposure, but it is considered a low risk at this time.

Risk Summary

Most of Missouri's sinkholes are naturally occurring. Since it is possible to determine the geographical extent of this hazard in most cases, mitigation can be targeted. Avoiding the hazard is much more cost effective than altering or mitigating the sinkhole itself. Some counties, such as Greene and Christian, limit construction in areas near sinkholes with building code and floodplain management practices.

Problem Statement:

Using the total value of structures exposed to risk in the karst areas of the state as a key indicator, the data suggests that St. Louis, Greene, Perry, Christian, and St. Charles Counties and the City of St. Louis would prove the most likely areas affected by sinkhole damage. Mitigation efforts and dollars focused in these areas would be most feasible.

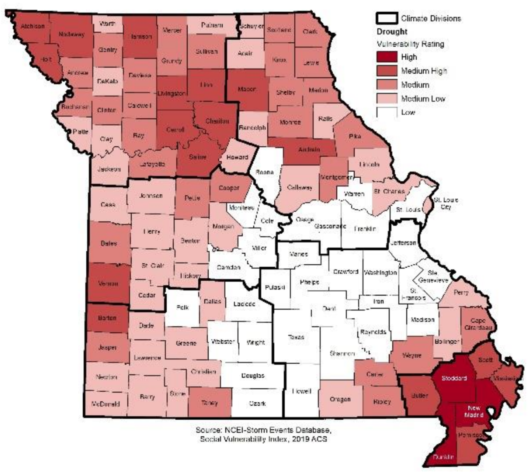
2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.6. Drought

Description

The National Weather Service defines drought as “a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people.” Droughts are regional climatic events which can impact large areas ranging from several counties in Missouri to the entire Midwestern region. Droughts can adversely affect a small town’s water supply, homeowners, small business owners, commodity markets, and tourism.

Vulnerability



Extent/Range of Intensity

The Palmer Drought Severity Index (PDSI) is one of the most common and longest-used indicators of drought severity. The PDSI measures the difference between water supply (in terms of precipitation and stored soil moisture) and demand (the amount of water required to recharge soil and keep rivers, lakes, and reservoirs at normal levels). The scale is from +4 to -4. Missouri has been susceptible to all levels of PDSI drought, including extreme moist spell (+4) to extreme drought (-4).

Probability	Severity	Location
6-11%	High	Statewide

State Vulnerability Overview

The agricultural sector suffers the greatest impacts during times of drought in Missouri. Areas prone to expansive soils can have greater movement during drought conditions that can impact foundations and infrastructure. Drought, as it affects the health and safety of Missouri citizens, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems at levels that have caused impacts to some smaller communities.

Changing Future Conditions Considerations

The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating that the periods between heavy rainfalls will be marked by an increasing number of dry days. Higher temperatures and increased evapotranspiration increase the likelihood of drought. This could lead to agricultural drought and suppressed crop yields.

Risk Summary/Problem Statement

The impacts of drought are diffuse and far-reaching. Sector impacts beyond agriculture include water supply and quality, relief, response, and restrictions, plants and wildlife, business and industry and tourism and recreation. Severe drought also poses health threats to citizens due to water shortages and can be exacerbated by extreme heat. Particularly vulnerable are children, the elderly, and those with respiratory problems.

Description/Location

Droughts are regional climatic events which can impact large areas ranging from several counties in Missouri to the entire Midwestern region. Areas with extensive agricultural land use can experience particularly significant impacts. Drought is not a hazard that affects just farmers, but can impact the nation's entire economy. Its outcome can adversely affect a small town's water supply, homeowners, small business owners, commodity markets, and tourism.

The National Weather Service defines drought as "a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people." The Missouri Drought Response Plan distinguishes between five categories of drought, as follows:

- **Agricultural Drought**—Defined by soil moisture deficiencies
- **Hydrological Drought**—Defined by declining surface and groundwater supplies
- **Meteorological Drought**—Defined by precipitation deficiencies
- **Hydrological Drought and Land Use**—Defined as a meteorological drought in one area that has hydrological impacts in another area
- **Socioeconomic Drought**—Defined as drought that impacts supply and demand of some economic commodity

Each of these definitions relates the occurrence of drought to water shortfall in some component of the hydrological cycle. Each affects patterns of water and land use, and each refers to a repetitive climatic condition. In urban areas, drought can affect those communities that depend on reservoirs for water, and decreased water levels due to insufficient rain can lead to restricted water use. In agricultural areas, drought during the planting and growing season can have a significant impact on yield.

Regardless of the specific definition, droughts are difficult to predict or forecast, both as to when they will occur and how long they will last. According to Dr. Grant Darkow, Department of Atmospheric Science, University of Missouri–Columbia, there is a recognizable *"upper air-flow pattern and simultaneous surface pattern associated with abnormal dryness over Missouri."* When the upper air-flow pattern is typified by air flowing in a broad arc over the central plains with higher speeds in southern Canada than over the United States, then the air over the southern plains will be *"characterized by a weak clockwise circulation."* Storm systems coming off the Pacific Ocean will cross the extreme northwestern states and southern Canada, thus bypassing the Midwestern states. When this flow pattern persists, the result can be a prolonged period of drought.

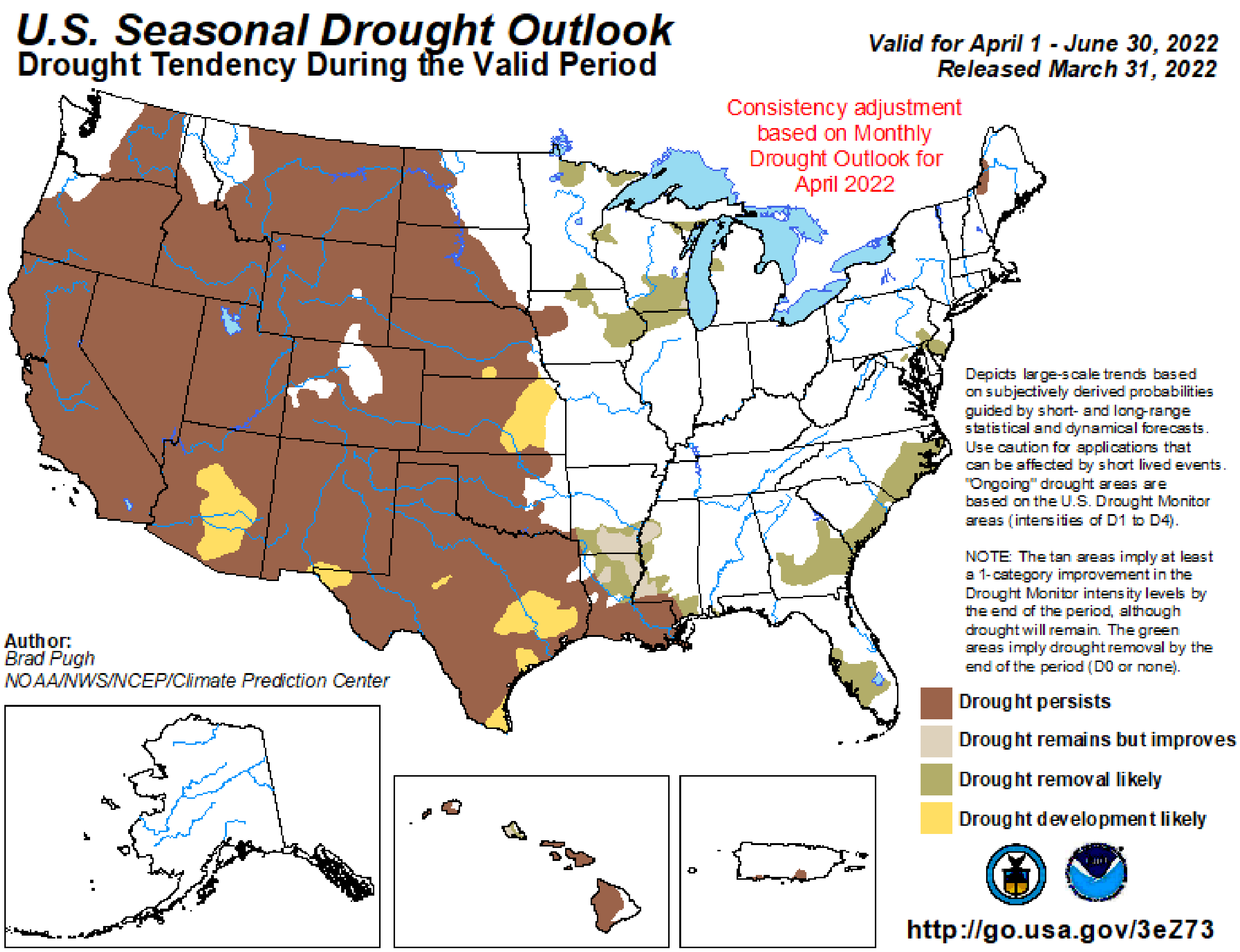
According to the Missouri Climatic Atlas for Design of Land Application Systems (MDNR-WP-1400) Missouri's average annual rainfall ranges from about 33.6 inches in the northwest to about 51 inches in the southern tier of the Missouri bootheel. Even the driest areas of Missouri have more rainfall than most western states; however, lack of rainfall impacts certain parts of the State more than others because of alternate source availability and usage patterns.

Southern Missouri—Most of the southern portions of Missouri are less susceptible to problems caused by prolonged periods without rain because of abundant groundwater resources in the region. Even with decreased stream flows or lowered reservoir levels, groundwater is still a viable resource in southern Missouri. Row-crop farming is not extensive; therefore agricultural needs aren't as great as in other

parts of the State. The only exception is in the southwestern and southeastern areas where irrigation is used.

Northern and West Central Missouri—Most of the northern and west-central portions of Missouri are underlain by rocks that are not conducive to water-bearing formations. They yield only small amounts of water, even during periods of normal and above-normal rainfall. Under drought conditions, adequate amounts of water cannot be pumped from the rock formations of northern Missouri to supply even domestic needs. Most streams in northern Missouri do not receive appreciable groundwater recharge. During periods of drought, these streams are generally reduced to a series of pools, or may become completely dry. Streams and water impoundments are the only localized sources of water during droughts, and even these limited resources are at risk when the drought is prolonged. Agriculture in west-central and northern Missouri is usually the first to feel the effects of drought. Although row-cropping is more extensive in this part of the State, irrigation is generally not feasible except on the floodplains of major rivers.

Figure 3.90. Drought Footprint



Extent /Range of Intensity

One of the most common and longest-used indicators of drought severity is the Palmer Drought Severity Index (PDSI), which is published jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA) (see **Table 3.50**). The PDSI measures the difference between water supply (in terms of precipitation and stored soil moisture) and demand (the amount of water required to recharge soil and keep rivers, lakes, and reservoirs at normal levels). The result is a scale from +4 to -4, at 1.0 and 0.5 intervals. By relating the PDSI to a regional index, one can compile data that reflects long-term wet or dry tendencies. Missouri has been susceptible to all levels of PDSI drought, including extreme drought.

Table 3.50. Palmer Drought Severity Index

PDSI Number	Long-Term Tendency
Above 4.0	Extreme moist spell
3.0 to 3.9	Very moist spell
2.0 to 2.9	Unusually moist spell
1.0 to 1.9	Moist spell
0.5 to 0.9	Incipient moist spell
0.4 to -0.4	Near normal conditions
-0.5 to -0.9	Incipient drought
-1.0 to -.9	Mild drought
-2.0 to -2.9	Moderate drought
-3.0 to -3.9	Severe drought
Below -4.0	Extreme drought

Source: NOAA

Missouri's Drought Response System outlined in the state's Drought Response Plan is divided into four phases, based on the PDSI:

Phase I: Advisory Phase—Requires a drought monitoring and assessment system to provide enough lead time for state and local planners to take appropriate action.

Phase II: Drought Alert—When the PDSI reads -1.0 to -2.0, and stream flows, reservoir levels, and groundwater levels are below normal over a several month period, or when the Drought Assessment Committee (DAC) determines that Phase II conditions exist based on other drought determination methods.

Phase III: Conservation Phase—When the PDSI reads -2.0 to -4.0, and stream flows, reservoir levels, and groundwater levels continue to decline, along with forecasts indicating an extended period of below-normal precipitation, or when the DAC determines that Phase III conditions exist based on other drought determination models.

Phase IV: Drought Emergency—When the PDSI is lower than -4.0, or when the DAC determines that Phase IV conditions exist based on other drought determination methods.

For PDSI reporting purposes, Missouri is divided into six regions of similar climatic conditions: Northwest, Northeast, West Central, Southwest, Southeast, and Bootheel.

One difficulty with recognizing or predicting drought is that no single indicator can be reliably used to predict onset. Regional indicators such as the PDSI are limited in that they respond slowly to deteriorating conditions, whereas observations of surface conditions and groundwater measurements or rainfall may only provide a “snapshot” of a very small area.

The U.S. Drought Portal, a product of the National Integrated Drought Information System (NIDIS), is also used in Missouri to monitor drought.

The U.S. Drought Portal is part of an interactive system to:

- Provide early warning about emerging and anticipated droughts
- Assimilate and quality control data about droughts and models
- Provide information about risk and impact of droughts to different agencies and stakeholders
- Provide information about past droughts for comparison and to understand current conditions
- Explain how to plan for and manage the impacts of droughts
- Provide a forum for different stakeholders to discuss drought-related issues

A major component of this portal is the **U.S. Drought Monitor.** The Drought Monitor concept was developed jointly by the NOAA’s Climate Prediction Center, the National Drought Mitigation Center, and the USDA's Joint Agricultural Weather Facility in the late 1990s as a process that synthesizes multiple indices, outlooks and local impacts into an assessment that best represents drought conditions in a given year. The final outcome of each Drought Monitor is a consensus of federal, state, and academic scientists who are intimately familiar with the conditions in their respective regions.

Drought intensity is summarized in five categories (D0-Abnormally Dry to D4-Exceptional Drought), based on a synthesis of the various drought indicators. Descriptions of the Drought Monitor categories, possible impacts, and comparisons with the PDSI and Standardized Precipitation Index are noted in **Table 3.51**.

Table 3.51. Drought Monitor Categories and Description

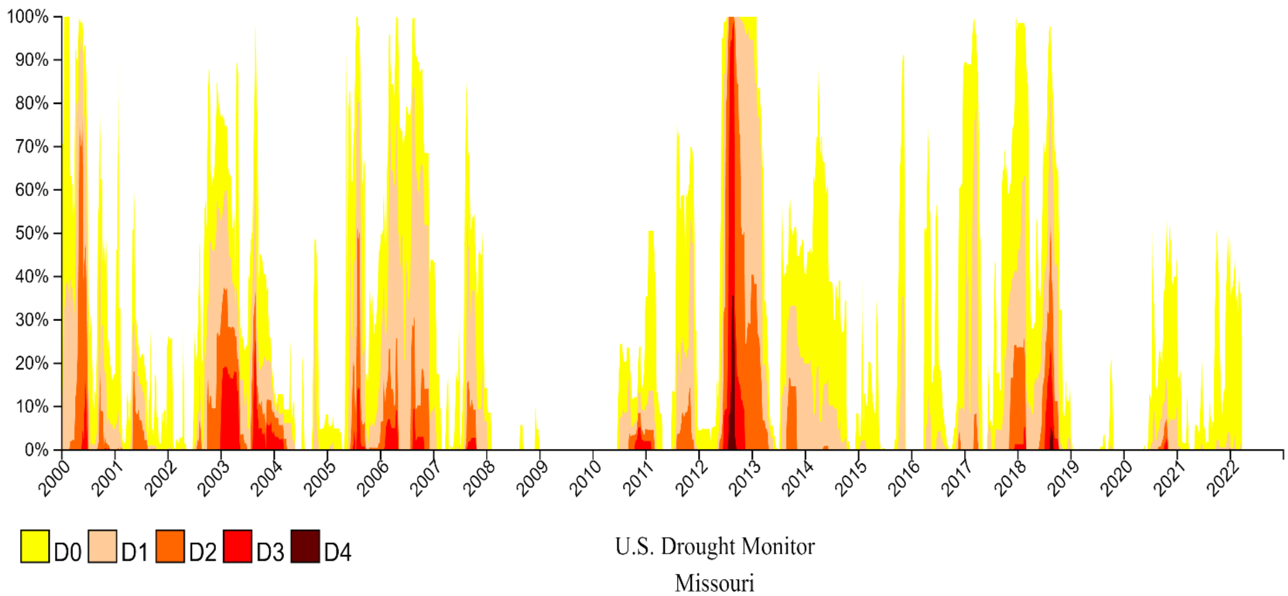
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	Standardized Precipitation Index (SPI)
D0	Abnormally Dry	Going into drought: - Short-term dryness slowing planting, growth of crops or pastures Coming out of drought: - Some lingering water deficits - Pastures or crops not fully recovered	-1.0 to -1.9	-0.5 to -0.7
D1	Moderate Drought	- Some damage to crops, pastures - Streams, reservoirs or wells low, some water - Shortages developing or imminent - Voluntary water-use restrictions requested	-2.0 to -2.9	-0.8 to -1.2
D2	Severe Drought	- Crop or pasture losses likely - Water shortages common - Water restrictions imposed	-3.0 to -3.9	-1.3 to -1.5
D3	Extreme Drought	- Major crop/pasture losses - Widespread water shortages or restrictions	-4.0 to -4.9	-1.6 to -1.9
D4	Exceptional Drought	- Exceptional and widespread crop/pasture losses - Shortages of water in reservoirs, streams and wells creating water emergencies	-5.0 or less	-2.0 or less

Source: United States Drought Monitor

Previous Occurrences

The National Drought Monitor provides an indication of when and how extensive drought has been statewide since it was initiated in 2000. **Figure 3.91 i**s a time series graphic of National Drought Monitor drought categories, which shows the cyclical nature and variable extent of drought conditions across the state. The 2012-2013 drought was the most severe and most extensive in that time period based on the figure below.

Figure 3.91.   Percent of Missouri in Drought 2000-2022



Source: The U.S. Drought Monitor, https://www.drought.gov/states/missouri

Summaries of recent droughts, since 1999, in Missouri are noted in the following table from various sources including the 2018 Missouri Hazard Mitigation Plan and NOAA documents (See **Table 3.52)**. The 2012-2013 drought was a significant event that impacted the entire state as well as much of the Midwestern United States. An analysis of NOAA Palmer Drought Severity Index data between 1900-2022 showed that significant droughts have also occurred in 1918, 1934 ('dust bowl' drought), 1954-56, 1964, and 1980.

Table 3.52.   Summaries of Recent Missouri Droughts

DATE	DESCRIPTION
July 1999 to November 1999	In September 1999, a Phase I Drought Advisory was declared for the state of Missouri. Governor Carnahan declared an agricultural emergency for the entire state. Agricultural reporting showed a 50 percent crop loss from the drought in 50 counties, with severe damage to pastures for livestock, corn crops, and Missouri's top cash crop—soybeans. On October 13, 1999, Dan Glickman, USDA secretary declared all Missouri counties agricultural disaster areas, making low-interest loans available to farmers in Missouri and contiguous states. The drought intensity increased through autumn and peaked at the end of November 1999. In fact, the five-month span between July and November became the second driest July-November period in Missouri since 1895, averaging only 9.38 inches of rain.

DATE	DESCRIPTION
March 2000 to May 2000	A wetter-than-normal winter diminished dry conditions in central and southern Missouri, but long- term moisture deficits continued to exist. At the same time, the remainder of the State (roughly north of the Missouri River) continued under drought conditions. Overall dry conditions returned through much of the State in March 2000, and costly wildfires and brush fires (70) erupted in many counties. By May, the entire state was under a Phase II Drought Alert level, and on May 23, Governor Carnahan announced activation of the Missouri Drought Assessment Committee (DAC), made up of state and federal agencies and chaired by Jeff Stake the MoDNR deputy director.
May 2000 to July 2000	At a May 25, 2000, meeting, the DAC selected a subcommittee (guided by the Missouri Drought Plan) to determine the drought status of each county. In June, based on observations across the State and projections of future rainfall, the committee upgraded the drought status for 27 northern Missouri counties to Phase III Conservation. This was based on concerns for water supplies and agricultural impacts. The City of Milan in Sullivan County was among the most severely affected in terms of water supplies. In June, a total of 80 Missouri counties remained under the Phase II Alert level, while 7 counties in southeast Missouri (Butler, Dunklin, Mississippi, New Madrid, Pemiscot, Scott, and Stoddard) remained under Phase I Advisory conditions. By mid-July 2000, some areas of northern Missouri benefited from additional rainfall, while drier conditions prevailed in other areas. At its July 12 meeting, the DAC revised its assessment, placing 30 counties under Phase III Conservation conditions, including 10 counties in the south-central area. The remaining 84 counties in the State were under Phase II Drought Alert conditions. This included seven counties in northern Missouri, which were downgraded from Phase III Conservation, and seven counties in Southeast Missouri, which were previously assessed as Phase I Advisory. To ease the agricultural impact of the drought during the summer months, Governor Carnahan gained release of over one million acres from the Conservation Reserve Program (CRP) to provide farmers and ranchers in 21 counties additional sources to cut hay for livestock feed. Also, livestock producers in 16 counties were released from CRP contracts to allow cattle grazing on certain idle lands.
2002 to June 2004	The drought of 2002 caused tremendous financial hardships to many Missouri crop and livestock producers. The financial impact of the drought on producers in turn impacted the local communities and the State in terms of reduced economic activity. This drought cost an estimated $46 million in 2002 and $575 million for 2003 in terms of Missouri’s agricultural and economic productivity. Drought conditions encompassed most of the northwestern quarter of Missouri. Severe drought conditions affected the northwest, west-central, and some portions of southwest Missouri, causing water conservation measures to be taken and restrictions to be imposed. For some areas, this was the second driest year since 1914. The only drier year was in 1988. 2002 had the driest November– December period on record for northwestern and north-central Missouri. The drought continued through 2003 and 2004 with conditions improving in 2004. As of March 3, 2004, drought conditions still encompassed most of the northwestern quarter of Missouri with 18 counties designated as being in Phase III Conservation. The drought conditions improved due to an increase in precipitation between March and June 2004. In June 2004, Missouri was considered drought-free for the first time in three years.
July 2005 to September 2005	The drought of 2005, as in the previous drought of 2003-2004, caused tremendous hardships to many Missouri crop and livestock producers. According to the University of Missouri’s Food and Agriculture Institute, the estimated losses to the corn and hay crops alone will likely top $370 million. For some Missouri farmers, this will be a drier year than 1988. By late July, the drought conditions encompassed all but nine counties in the northwestern corner of the State. Severe drought conditions affected counties in the southwest through the northeast part of the State. Effective August 23, 2005, due to the secretarial disaster designation, 114 Missouri counties and St. Louis City were designated as natural disasters for physical and/or production-loss loan assistance from Farm Service Agency (FSA). The drought conditions began to improve by late August and into September.

DATE	DESCRIPTION
September 2006 to December 2006	The drought of 2006 has had a tremendous agricultural impact on Missouri farmers. As of September 2006, FSA reported that 26 counties had requested Emergency Conservation Program (ECP) funds with two additional counties pending. The livestock industry is feeling severe effects from the current drought. Hay supplies are short, and water supplies for livestock continue to decline. USDA reported that the new $50 million program for livestock producers, called the Livestock Assistance Grant Program, will provide this money in Section 32 to states in block grant form. The drought has also had an impact on local water supplies with several communities issuing mandatory conservation measures. On September 19, 2006, only 10 counties in the southeastern portion of the State were free of drought. By November 28, 2006, 5 more counties were drought-free and 11 more had entered Phase III for a total of 49 counties in the Conservation Phase. In October 2006, the USDA designated 85 Missouri counties as a primary natural disaster area (and extended assistance eligibility to 20 contiguous counties) due to losses caused by the drought beginning January 1, 2006. Only the southeast corner and the extreme northwest corner were not eligible for assistance. According to Pat Guinan, University of Missouri climatologist, a snowstorm in late November/early December put a dent in the drought, but more rain and snow are needed for conditions to return to normal.
February 2007 to October 2007	No serious drought conditions have been reported since 2006. The Interim Drought Status map (February 13, 2007) indicates that there were 76 counties in Phase I—Advisory Phase, and 38 counties with no drought. The U.S. Drought Monitor map (July 31, 2007) indicates that several counties north of I-70 and all counties along the Mississippi River to the south had abnormally dry conditions. The Palmer Drought Severity Index map for October 16, 2007, forecasts moderate to extreme drought for most of the counties in Missouri. On October 23, 2007 (see Fig. 3.22) shows that there were 61 counties with no drought, 33 counties in Phase I—Advisory Phase, and 20 counties Phase II—Drought Alert.
June 2010 to March 2011	Starting in July 2010, precipitation levels dropped as temperatures remained high, stressing crops in southeast Missouri. Rainfall in late July and August and Tropical Storm Hermine in September gave little relief as water shortage continued. Continued lack of rainfall led to severe (D2) drought conditions in September and extreme (D3) conditions in October the Bootheel region of Missouri. The drought expanded north and west during October and wildfire risk increased due to the dry conditions. Several wildfires occurred in November in Wayne and Carter counties. Precipitation in February provided some relief from the drought and reduced conditions back to severe, then additional rainfall in March further improved the drought status in Missouri.
July 2011 to November 2011	The south west region of Missouri experienced severe (D2) drought at the end of July 2011. Crops were hard hit, and many failures were reported. Crop damages up to $10 million were recorded along with reports of impacts to livestock and their feed. Rainfall in November was double the normal amount for the month and helped to reduce the level of drought to moderate (D1) or abnormally dry (D0).
May 2012 to January 2013	May of 2012 brought below average rainfall and resulted in crop damage, low soil moisture levels, and reduced stream flows. By the end of the month, the southern and Bootheel regions of Missouri reached a severe (D2) level drought. In June the drought worsened, meriting an upgrade to an extreme (D3) drought. Fire warnings were high, soybean, corn, and sorghum crops became stressed, and soils moisture levels continued to drop. The drought expanded further into the Ozarks, East Central, Northeast, and Southeast Missouri by the end of June. During July, the drought level was heightened to exceptional (D4) conditions. Crops continued to decline and more livestock had to switch to hay bales for feed. Fourth of July fireworks were canceled due to the dangerously dry conditions. The drought continued for the remainder of 2012 and into early 2013. The majority of the state remained at a severe (D2) drought condition as of January 2013 until conditions improved in the remainder of 2013. All counties in Missouri were declared disaster areas due to the drought.
November 2016 to December 2016	Severe drought conditions spread into extreme southeast Missouri. A lack of precipitation caused soil moisture to decrease rapidly. Pastureland deteriorated, causing some farmers to begin feeding hay to livestock. Stock ponds began to run low. Some farmers began hauling in water for their livestock. Only about one-quarter inch of rain fell during the first few weeks of November. This lack of precipitation, combined with above normal temperatures, contributed to the rapid onset of drought conditions. At Paducah, 1.28 inches of rain fell from September 1 to November 18. This was 8.69 inches below normal for that period. Small streams as well as larger rivers were running well below normal. A heavy rainfall event late in the month brought some improvement in the drought.

DATE	DESCRIPTION
June 2018 to October 2018	The anomalously dry period that plagued the region during the summer of 2018 continued into and through July. Most areas were about 2 inches short of normal precipitation for the month of July. Most of northern Missouri, north of the Missouri River, came up between 4 and 5 inches short of normal. This combined with the dry June has caused the drought across the region to worsen. The drought of 2018 continued across the State until October, however an influx of some moisture in September brought some minor relief to the county. Conditions improved from D3 to D2 during the month of September, but the impacts and losses of several crops were already felt across the region. The amount of damage is unknown, but numerous farmers were unable to get full return from their crops.
October 2020 to November 2020	Through the first 3 weeks of October, there was less than half an inch of rain fall across the county and extreme (D3) drought conditions developed. The primary concerns were focused on ground water and surface water where low stream flows, lakes levels and some impacts to monitoring wells occurred. Much of the impacts felt through the increasing drought were limited by the end of the growing season. Primary impacts were limited for the most part to surface and ground water issues and fire weather concerns. A pattern shift occurred during the last week of the month bringing significant rainfall and drought conditions improving to Severe (D2) drought by the end of the month. Drought continued into November.

Probability of Future Hazard Events

Because of its geographical location and characteristic weather patterns, Missouri is vulnerable to drought conditions. Agricultural droughts are the most common on record, particularly those inflicting damage to corn crop yields. Throughout much of the previous 122 years, these droughts have occurred with common regularity (on the average of once every five years), according to the Missouri Crop and Livestock Reporting Service. **Figure 3.92** depicts the percent of time in extreme or severe drought, based on 122 years of PDSI data (1900-2022). North of the Missouri River the state can be expected to be in extreme or severe drought between 9-10.72% of the time; south of the River 5.87-8% of the time.

The Center for Disease Control and Prevention (CDC) also provides tracking information on drought through National Environmental Public Health tracking. This tracking network includes data on drought duration and severity from the United States Drought (USDM) and the Standardized Precipitation Evapotranspiration (SPEI) to track drought trends in the United States. **Figure 3.93** was prepared to present the percent of time in extreme or severe drought, based on 42 years of this tracking data (1980-2021). For this more recent dataset, the northwestern portion of the state can be expected to be in extreme or severe drought between 22.39-24.08% of the time; and for the southeastern portion 21.02-22.39% of the time. This presents a slight transition from the larger historical dataset.

Figure 3.92. Drought Probability by Climate Division Based on Palmer Drought Severity Index 1895-2016

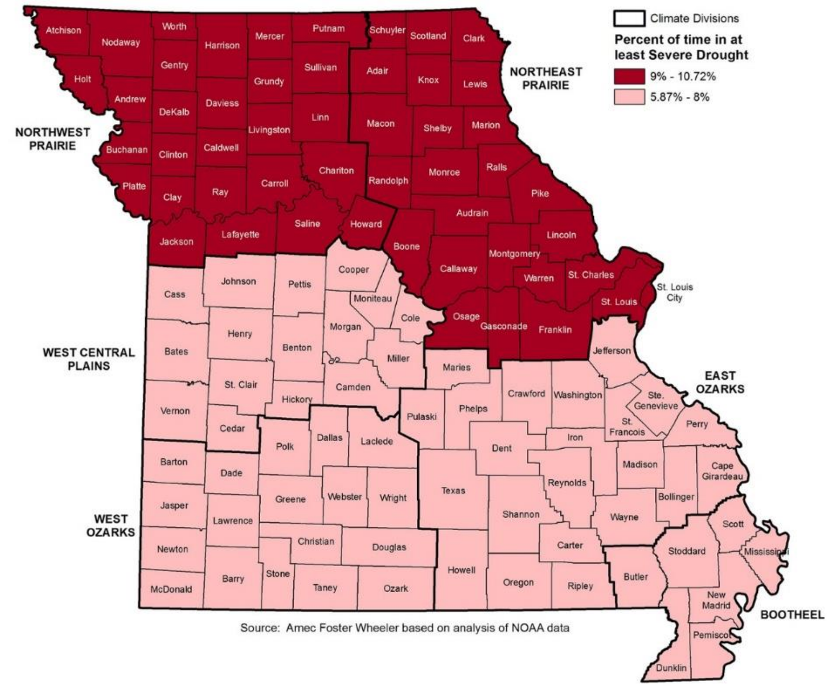
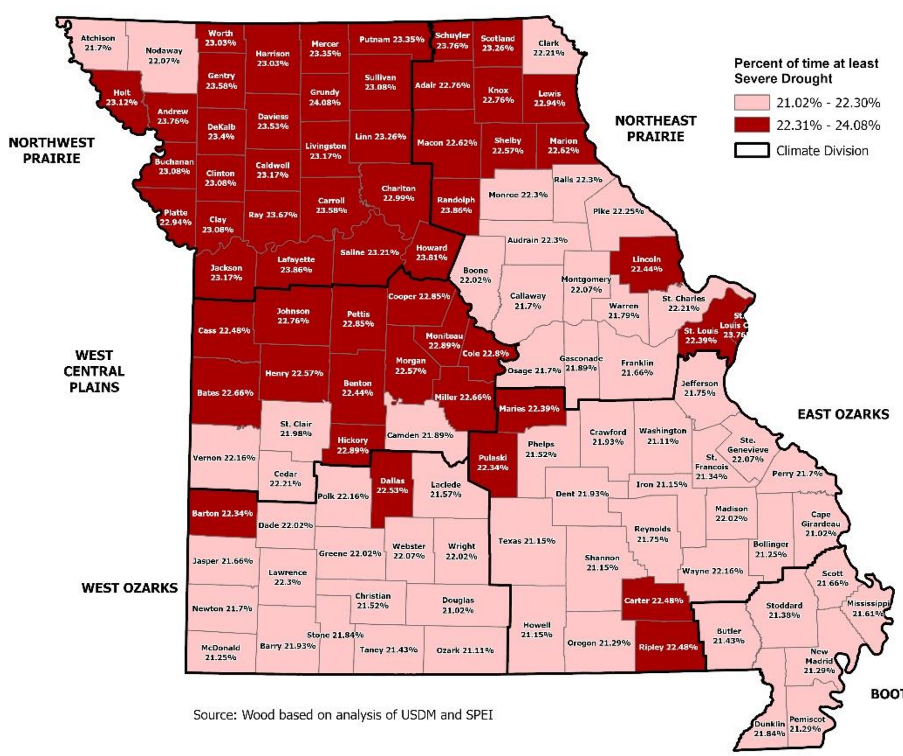


Figure 3.93. Drought Probability by Climate Division Based on USDM and SPEI Data 1980-2021



Changing Future Conditions Considerations

Severe drought, a natural part of Missouri's climate, is a risk to this agriculture-dependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally-occurring droughts.

Although springtime in Missouri is likely to be wetter, summer droughts are likely to be more severe. Higher evaporation and lower summer rainfall are likely to reduce river flows. The drought of 2012 narrowed navigation channels, forced lock closures, and caused dozens of barges to run aground on the Mississippi River along the Missouri shoreline. The resulting impact on navigation cost the region more than $275 million. The drought of 2012–2013 also threatened municipal and industrial water users along the Missouri River.

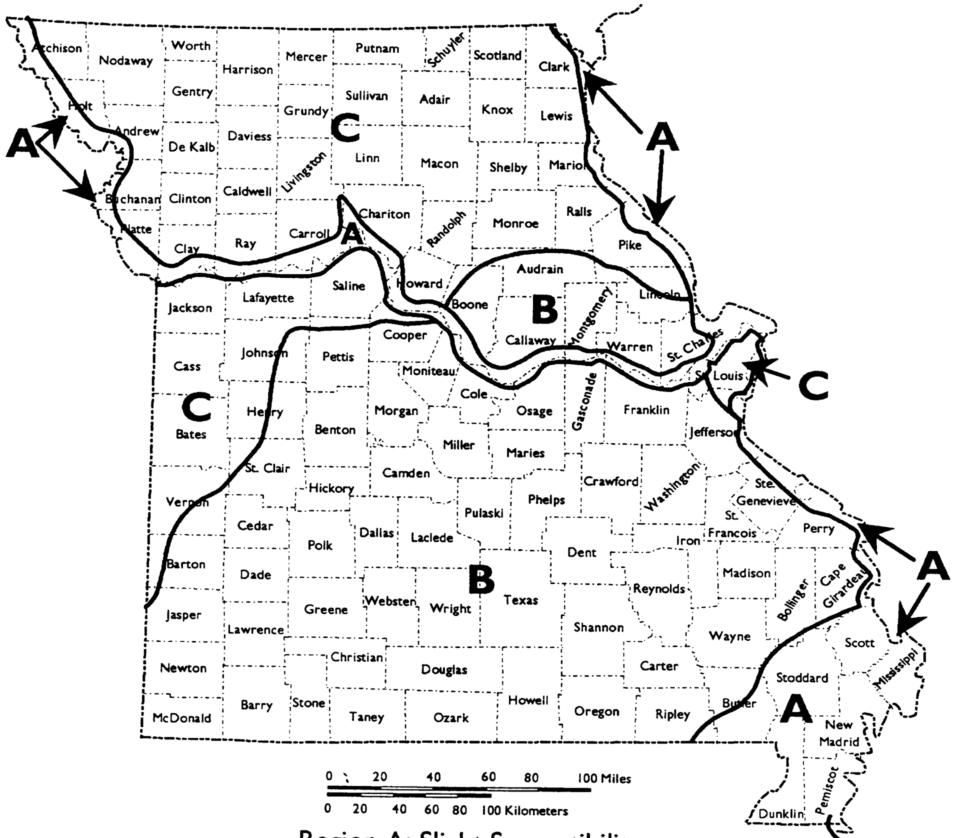
The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating that the periods between heavy rainfalls will be marked by an increasing number of dry days. Higher temperatures and increased evapotranspiration increase the likelihood of drought. This could lead to agricultural drought and suppressed crop yields.

State Vulnerability Overview

The impacts and severity of drought on Missouri can be significant. The Missouri Drought Plan divides the State into three regions, which are prioritized according to drought susceptibility (see **Figure 3.94**). The regions are identified as having slight, moderate, and severe susceptibility to drought conditions. Descriptions of drought susceptibility for the three regions are as follows:

- **Region A (mostly southeast Missouri)** has very little drought susceptibility. It is a region underlain by sands and gravel (alluvial deposits). Surface and groundwater resources are generally adequate for domestic, municipal, and agricultural needs.
- **Region B (central, east-central Missouri)** has moderate drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs, but due to required well depths, irrigation wells are very expensive. The topography is generally unsuitable for row-crop irrigation.
- **Region C (northern, west-central Missouri; St. Louis County)** has severe drought vulnerability. Surface water sources usually become inadequate during extended drought. The groundwater resources are normally poor, and typically supply enough water only for domestic needs. Irrigation is generally not feasible. When irrigation is practical, groundwater withdrawal may affect other uses. Surface water sources are used to supplement irrigation supplied by groundwater sources.

Figure 3.94. Missouri Drought Susceptibility



Region A: Slight Susceptibility
Region B: Moderate Susceptibility
Region C: High Susceptibility

Source: Missouri Drought Plan, 2002

The National Drought Mitigation Center launched the Drought Impact Reporter (DIR) in July 2005 as the nation's first comprehensive database of drought impacts. The DIR summarizes information from media reports, user-supplied reports, National Weather Service Drought Information Statements, Community Collaborative Rain, Hail and Snow network, and other agency reports. A report is defined as 'An observable loss or change that occurred at a specific place and time because of drought.' Reports are collected at state and county levels, where possible, and data can be accessed and queried through an online map service.

The Drought Impact Reporter contains information on 321 drought impacts from droughts that affected Missouri between January 1, 1980 and March 31, 2022. Most of the impacts, 213 were classified as "agriculture." Other impacts include "water supply and quality" (60), "relief, response, and restrictions" (86), "plants and wildlife" (44), "fire" (12), "society and public health" (60)", "business and industry" (47), "tourism and recreation" (3) and "energy" (7). In many cases the recorded impact includes several of the above categories. These categories are described as follows:

- **Agriculture**—Drought effects associated with agriculture, farming, aquaculture, horticulture, forestry, or ranching. Examples of drought-induced agricultural impacts include damage to crop quality; income loss for farmers due to reduced crop yields; reduced productivity of cropland;

insect infestation; plant disease; increased irrigation costs; cost of new or supplemental water resource development (wells, dams, pipelines) for agriculture; reduced productivity of rangeland; forced reduction of foundation stock; closure/limitation of public lands to grazing; high cost or unavailability of water for livestock, Christmas tree farms, forestry, raising domesticated horses, bees, fish, shellfish or horticulture.

- **Business & Industry**—This category tracks drought's effects on non-agriculture and non-tourism businesses, such as lawn care, recreational vehicles or gear dealers, and plant nurseries. Typical impacts include reduction or loss of demand for goods or services, reduction in employment, variation in number of calls for service, late opening or early closure for the season, bankruptcy, permanent store closure, and other economic impacts.
- **Energy**—This category concerns drought's effects on power production, rates, and revenue. Examples include production changes for both hydropower and non-hydropower providers, changes in electricity rates, revenue shortfalls and/or windfall profits, and purchase of electricity when hydropower generation is down.
- **Fire**—Drought often contributes to forest, range, rural, or urban fires, fire danger, and burning restrictions. Specific impacts include enacting or easing burning restrictions, fireworks bans, increased fire risk, occurrence of fire (number of acres burned, number of wildland fires compared to average, people displaced, etc.), state of emergency during periods of high fire danger, closure of roads or land due to fire occurrence or risk, and expenses to state and county governments of paying firefighters overtime and paying equipment (helicopter) costs.
- General Awareness
- **Plants & Wildlife**—Drought effects associated with unmanaged plants and wildlife, both aquatic and terrestrial, include loss of biodiversity of plants or wildlife; loss of trees from rural or urban landscapes, shelterbelts, or wooded conservation areas; reduction and degradation of fish and wildlife habitat; lack of feed and drinking water; greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion; disease; increased vulnerability to predation (from species concentrated near water); migration and concentration (loss of wildlife in some areas and too much wildlife in others); increased stress on endangered species; salinity levels affecting wildlife; wildlife encroaching into urban areas; and loss of wetlands.
- Relief, Response and Restrictions
- **Society & Public Health**—Drought effects associated with human, public and social health include health-related problems related to reduced water quantity and/or quality, such as increased concentration of contaminants; loss of human life (e.g. from heat stress, suicide); increased respiratory ailments; increased disease caused by wildland fire concentrations; increased human disease caused by changes in insect carrier populations; population migration (rural to urban areas, migrants into the United States); loss of aesthetic values; change in daily activities (non-recreational, like putting a bucket in the shower to catch water); elevated stress levels; meetings to discuss drought; communities creating drought plans; lawmakers altering penalties for violation of water restrictions; demand for higher water rates; cultural/historical discoveries form low water levels; prayer meetings; cancellations of fundraising events; cancellation/alteration of festivals or holiday traditions; stockpiling water; public service announcements and drought information websites; protests; and conflicts within the community due to competition for water.

- **Tourism & Recreation**—Drought effects associated with recreational activities and tourism include closure of state hiking trails and hunting areas due to fire danger; water access or navigation problems for recreation; bans on recreational activities; reduced license, permit, or ticket sales (e.g. hunting, fishing, ski lifts, etc.); losses related to curtailed activities (e.g. bird watching, hunting and fishing, boating, etc.); reduced park visitation; and cancellation or postponement of sporting events.
- **Water Supply & Quality**—Drought effects associated with water supply and water quality include dry wells, voluntary and mandatory water restrictions, changes in water rates, easing of water restrictions, increases in requests for new well permits, changes in water use due to water restrictions, greater water demand, decreases in water allocation or allotments, installation or alteration of water pumps or water intakes, changes to allowable water contaminants, water line damage or repairs due to drought stress, drinking water turbidity, change in water color or odor, declaration of drought watches or warnings, and mitigation activities.

The DIR data indicates that the agricultural sector suffers the greatest impacts during times of drought in Missouri. This is supported by analysis of drought-related crop losses discussed later in this section.

While data on structure impacts from drought is sparse, areas prone to expansive soils can have greater movement during drought conditions that can impact foundations and infrastructure. A DIR report submitted August 15, 2012 sourced from the St. Louis Post-Dispatch noted that basement repair businesses in the St. Louis area received a high volume of phone calls from homeowners needing repairs as the drought causes soil to shift, damaging home foundations. The wait for repairs, which can run in the tens of thousands of dollars, was two months or longer for some businesses. One repairman had never seen as many problems with foundations as this in his 28 years of work. One repair firm said they had twice to three times the usual number of jobs lined up. Much of the soil in the St. Louis area is high in clay, which shrinks as the soil dries, triggering cracking in walls.

Other economic impacts can result from the need to deepen existing wells or drill additional wells. This was observed by the Missouri Department of Natural Resources (MoDNR) during the 2006 drought in southwest Missouri because the drought was so extreme there. Drillers in southwestern Missouri must make wells 500 to 600 feet deep to find adequate water supplies that once were found at a depth of 300 feet. Drought has impacted barge traffic on the Missouri and Mississippi Rivers as underwater obstructions pose problems for navigation due to low water levels.

Drought, as it affects the health and safety of Missouri citizens, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems at levels that have caused impacts to some smaller communities. Most seriously affected are those supplied by small water supply structures. In its scope, a drought may be limited to a localized problem, or even a regional problem. Based on severity and duration, it may even become a statewide problem, at least in terms of overall impact, such as the commitment and shifting of resources and other response issues. Good water quality and a plentiful supply are two factors that are often taken for granted. But when good water becomes a scarce commodity and people must compete for the available supply, the importance of these two factors increases dramatically. Missouri's Resources Plan (*RSMo 640.415*), which is a provision of the Water Resources Law enacted by the Missouri Legislature in 1989, requires MoDNR to ensure that the quality and quantity of Missouri's water resources are maintained at the highest possible level to support present and future beneficial uses. The provision was established to provide for the development, maintenance, and periodic updating of a long-range comprehensive statewide plan

for the use of surface water and groundwater. It includes existing and future requirements for drinking water supplies, agriculture, industry, recreation, environmental protection, and related needs.

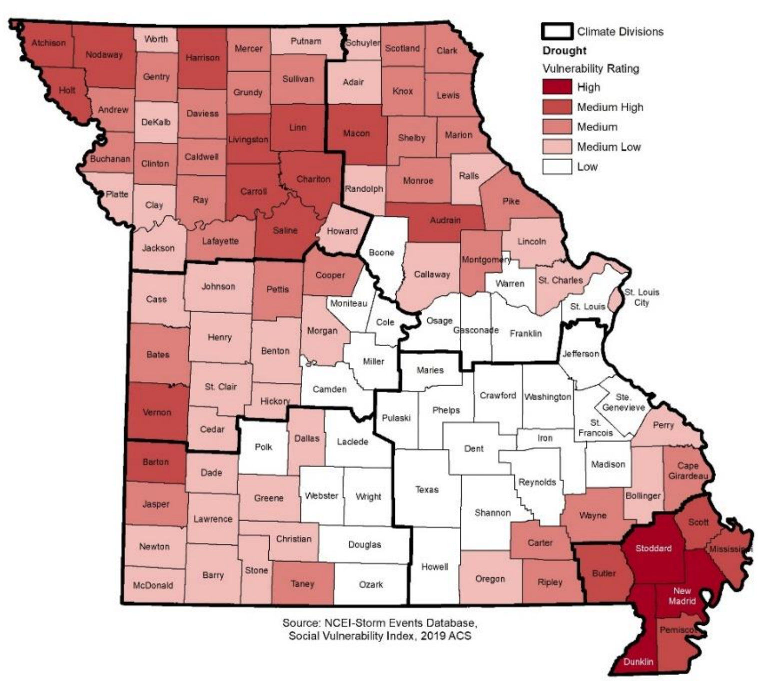
The method used to determine vulnerability to drought across Missouri was a statistical analysis of data from several sources: USDA Risk Management Agency's insured crop losses as a result of drought (2021-2022), USDA crop exposure by county, the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina, and storm events data (1996 to December 31, 2021) and probability of severe drought based on historic Palmer Drought Severity Index. The USDA crop exposure by county is from the 2017 Agricultural Census and assumes that the larger the exposure, the greater potential for loss and impact on the local economy.

From the statistical data collected, four factors were considered in determining overall vulnerability to drought as follows: social vulnerability, crop exposure ratio, annualized crop claims paid, and likelihood of occurrence. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. Once the ranges were determined and applied to all factors considered in the analysis, the ratings were combed to determine an overall vulnerability rating for drought. These rating values correspond to the following descriptive terms:

1) Low
2) Medium-low
3) Medium
4) Medium-high
5) High

All county-level statistical data tables, including ranges for vulnerability factor ratings, are presented in Appendix A. **Figure 3.95** shows the darker shaded counties as the most vulnerable to drought.

Figure 3.95. Missouri Drought Vulnerability by County



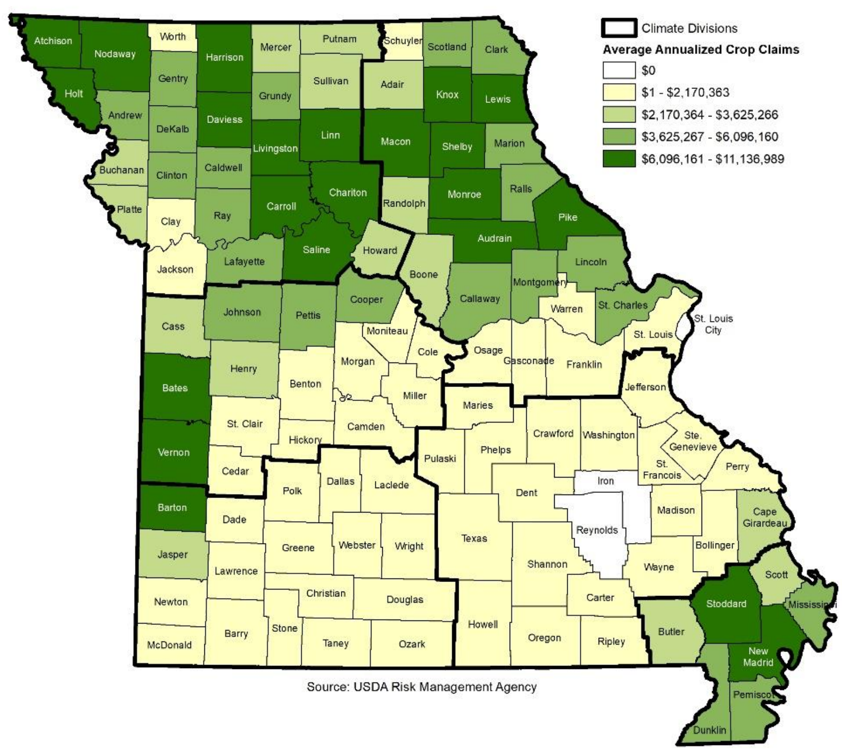
According to this analysis, the counties with a high vulnerability to drought are Dunklin, New Madrid, and Stoddard Counties.

State Estimates of Potential Losses

Determining the direct and indirect costs associated with drought is difficult because of the broad impacts of drought and the difficulty in establishing when droughts begin and end. The impacts of drought have been assessed through the vantage point of agricultural losses, primarily due to the excellent agricultural statistical and insurance data that is available and the fact that agricultural impacts are noted as the most prevalent impact from the Drought Impact Reporter Analysis. As part of the update process, SEMA revisited available data sets to determine if additional assessments are possible, but determined that data to support drought losses to other sectors was not readily available for analysis.

The drought loss estimation methodology uses USDA Risk Management Agency's crop insurance claims paid in Missouri from 2012-2021 and the USDA's crop exposure value by county to determine the Annualized Drought Crop Insurance Claims Paid as mapped in **Figure 3.96**. USDA Risk Management Agency's crop insurance claims paid as a result of drought conditions during this time period totaled $3,540,982,039. This results in a statewide annualized loss of $354,098,203. This data is provided for all Missouri counties. Crop insurance claims data were obtained for all hazards that resulted in payment of claims.

Figure 3.96. Annualized Drought Crop Insurance Claims Paid from 2012-2021



The Central US 2012 Drought Assessment report contained a state-by state assessment of the drought conditions and impacts. An income assessment on the effects of the 2012 drought on Missouri agriculture noted in this report concluded a loss of $1.07 billion dollars in farm income within the state.

Hazard Impact on Future Growth and Development

As counties experience significant increases in population it will create greater demands on water resources and potentially increase drought vulnerability. Of the counties that were determined to be highly vulnerable to drought as a result of this analysis, only Clinton County is in the group of Missouri Counties with a population growth rate of 5% or more (11.1%). In southwest Missouri growth and development alone could strain existing surface and ground water resources according to a study done in 2014 by the Missouri Department of Natural Resources and Army Corp of Engineers. The exact findings in the 16-county region in Southwest Missouri vary with weather and population models, but there is a consensus that a prolonged drought coupled with expected population growth means additional water sources will be needed, perhaps as early as 2030.

The 2020 Missouri Water Resources Plan identified the following key findings related to water resources and availability of a sustainable supply, including during times of drought:

- As water resource challenges evolve and emerge, there will be an increasing need for additional, high-quality data and improved data sharing among water users, managers, researchers and regulators.
- The growing need to repair and replace aging infrastructure will require careful planning, effective management, and creative funding solutions to ensure water rates remain affordable.
- An extended and/or severe drought would generate a high potential for water supply stress during multiple months of the year regardless of the potential future variations in demand, climate conditions, and water supply constraints.
- Groundwater users are generally less likely to experience increasing stress (reduced yields or dry wells) than surface water users under drought conditions.
- While a strong economy is a benefit to Missouri, it brings an increased likelihood of water stress and potential water shortages.
- Non-consumptive demands for power generation, commercial navigation, water-based outdoor recreation, aquaculture, and fish and wildlife, while more difficult to quantify, are important to Missouri and its growing economy.
- An adaptive approach to coordinated, long-term water planning and management is vitally important, especially given expected future variation in climate conditions, water demand, and other factors.

Areas that appear to be the most vulnerable to drought and water supply shortages should be the focus of future drought planning, management, and mitigation activities, and should again be considered in the next Missouri Drought Plan update.

Risk Summary

In Missouri, drought losses to crops alone have averaged about $50M annually over the past ten years. Sector impacts beyond agriculture include water supply and quality, relief, response, and restrictions, plants and wildlife, business and industry and tourism and recreation. The impacts of drought are so diffuse and far-reaching that financial estimates of loss beyond agriculture are difficult to quantify.

In addition to damage to crops, produce, livestock, and soil, and the resulting economic consequences, the arid conditions created by drought pose an increased risk of fire. The danger is especially high for

brush fires, grass fires, and fires in wooded areas, which can threaten homes and other structures in their path. Lack of water resources in rural areas can complicate the firefighting efforts.

Severe drought also poses health threats to citizens due to water shortages and can be exacerbated by extreme heat. Particularly vulnerable are children, the elderly, and those with respiratory problems. Contaminated or poor water quality for drinking and sanitation measures can also cause serious illnesses.

Problem Statement:

Using Annualized Drought Crop Insurance claims paid as a key indicator, the counties most likely to be impacted by drought are Audrain, Lewis, Stoddard, Carroll, Knox, Vernon, Chariton, Bates, Shelby, and Monroe. The data suggests that mitigation efforts and dollars allocated to these counties would be most beneficial.

2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

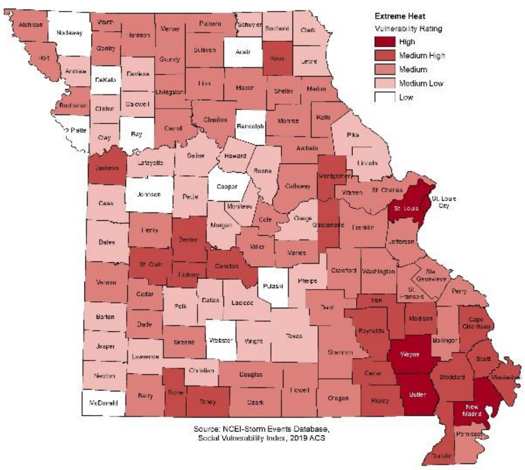
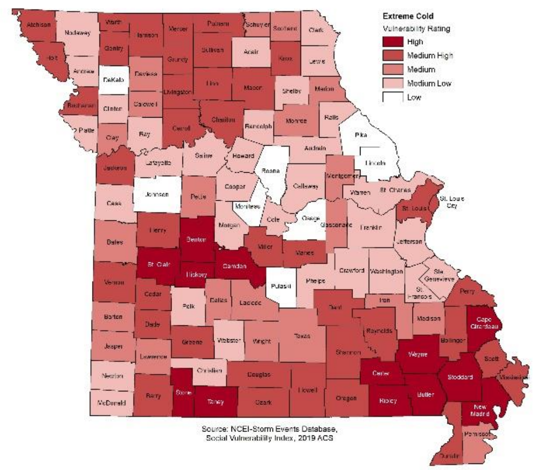
3.3.7. Extreme Temperatures

Description

Frequent changes in temperature are known to occur mainly because of the State's inland location. Extreme heat can be described as temperatures that hover 10°F or more above the average high temperature for a region during the summer months. Extreme cold temperatures drop well below what is considered normal for an area during the winter months and often accompany winter storm events.

Extent/Range of Intensity

Prolonged periods of extremely cold weather or heat are unusual, however temperatures above 100° F have occurred, as well as, temperatures below 0° F. The National Weather Service (NWS) issues heat-related and wind chill/freeze warnings, watches, advisories, and outlooks. The NWS local offices in Missouri may collaborate with local partners to determine when an alert should be issued for a local area.

Vulnerability – Extreme Heat	Vulnerability – Extreme Cold
	

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

The three counties rated "High" in overall vulnerability to extreme heat include Butler, New Madrid, and Wayne, and also the City of St. Louis. There were 13 counties that rated "High" in overall vulnerability to extreme cold: Benton, Butler, Camden, Cape Girardeau, Carter, Hickory, New Madrid, Ripley, St. Clair, Stoddard, Stone, Taney, and Wayne.

Changing Future Conditions Considerations

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the century. Temperature increases will cause future heat waves to be more intense, a concern for this region which already experiences hot and humid conditions. If the warming trends continue and cold wave intensity is projected to decrease.

Risk Summary/Problem Statement

Citizens of Missouri should be instructed to be aware of the warning signs of heat-related illness, such as light-headedness, mild nausea or confusion, sleepiness, or profuse sweating. Extreme cold can also be life threatening and cause injury and death due to hypothermia.

Description/Location

Missouri has a continental type of climate marked by strong seasonality. Frequent changes in temperature are known to occur mainly because of the State's inland location. Prolonged periods of extremely cold weather or heat are unusual, however temperatures above 100° F have occurred, as well as, temperatures below 0° F, which average 2 to 5 days per year in northern counties and 1 to 2 days per year in southern counties.

Extreme Heat/Heat Wave

Extreme heat can be described as temperatures that hover 10°F or more above the average high temperature for a region during the summer months. A heat wave is a period of excessive heat, which can lead to illness and other stress to people with prolonged exposure to these conditions. High humidity, which often accompanies heat in Missouri, can make the effects of heat even more harmful. While heat-related illness and death can occur from exposure to intense heat in just one afternoon, heat stress on the body has a cumulative effect. Consequently, the persistence of a heat wave increases the threat to public health. The National Weather Service (NWS) defines a heat wave as three consecutive days of temperatures of 90 degrees Fahrenheit (°F) and above. These high temperatures generally occur from June through September but are most prevalent in the months of July and August.

Ambient temperature is not the only factor considered when assessing the likely effects of heat. Relative humidity is also considered along with duration of exposure, wind, and activity. The NWS has stepped up its efforts to more effectively alert the general public and appropriate authorities to the hazards of heat waves. The NWS has devised a Heat Index (HI), which is a combination of air temperature and relative humidity that more accurately reflects the heat intensity. The HI, given in degrees Fahrenheit, is an accurate measure of how hot it really feels when the relative humidity is added to the actual air temperature. The Heat Index Chart is presented in **Figure 3.97.** As an example, if the air temperature is 96°F (found at the top of the table), and the relative humidity is 55 percent (found on the left of the table), the HI is 112°F (the intersection of the 96°F row and the 55 percent column). Because HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Along with humans, animals also can be affected by high temperatures and humidity. For instance, cattle and other farm animals respond to heat by reducing feed intake, increasing their respiration rate, and increasing their body temperature. These responses assist the animal in cooling itself, but this is usually not sufficient. The hotter the animal is, the more it will begin to shut down body processes not vital to its survival, such as milk production, reproduction, or muscle (meat) building.

Heat waves are often a major contributing factor to power outages (brownouts, etc.), as the high temperatures result in a tremendous demand for electricity for cooling purposes. Power outages for prolonged periods increase the risk of heat stroke and subsequent fatalities due to loss of cooling and proper ventilation.

Other related hazards include water shortages brought on by drought-like conditions and high demand. Local advisories, which list priorities for water use and rationing, are common during heat waves. Government authorities report that civil disturbances and riots are also more likely to occur during heat waves, as well as incidents of domestic violence and abuse. In cities, pollution becomes a problem

because the heat traps pollutants in densely developed urban areas. Adding pollution to the stresses of the heat magnifies the health threat to the urban population.

Figure 3.97. Heat Index Chart

NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

Source: National Weather Service; https://www.weather.gov/ama/heatindex
Note: The red area without numbers indicates extreme danger.

Extreme Cold

Extreme cold temperatures drop well below what is considered normal for an area during the winter months and often accompany winter storm events. Combined with increases in wind speed, defined as wind chill, such temperatures can be life threatening to those exposed for extended periods of time. Wind chill is determined by factoring cold temperatures and wind speed to determine the overall chill factor. For example when the temperature is 20°F and the wind speed is 15 miles per hour, the resulting wind chill (what it really feels like) is 6°F. This type of situation can be dangerous to people outdoors because their bodies can experience rapid heat loss, resulting in hypothermia (abnormally low

body temperature). Hypothermia or frostbite may be considered the most direct cause of death and injury that can be attributed to winter storms or severe cold.

The NWS Wind Chill Temperature (WCT) Index makes use of advances in science, technology, and computer modeling to provide a more accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures, see **Figure 3.98**.

In addition, clinical trials were conducted, and the results of those trials have been used to improve the accuracy of the WCT Index and determine frostbite threshold values. The current WCT Index, implemented in 2001, uses wind speed calculated at the average height of the human body's face (5 feet), is based on a human face model; incorporates modern heat transfer theory (heat loss from the body to its surroundings during cold and breezy/windy days); lowers the calm wind threshold to 3 miles per hour; uses a consistent standard for skin tissue resistance; and assumes the worst-case scenario for solar radiation (clear night sky).

An indirect winter hazard that affects Missourians every year is carbon monoxide (CO) poisoning. Improperly vented gas and kerosene heaters or the indoor use of charcoal briquettes creates dangerous levels of carbon monoxide. Between 1993 and 2015, there were 1,759 cases of CO poisoning, including 1,104 fatalities, in Missouri according to the Missouri Department of Health and Senior Services, see **0 below**.

Extent /Range of Intensity

Extreme Heat/Heat Wave

The National Weather Service issues some or all of the following heat-related products as conditions warrant across the State of Missouri. NWS local offices in Missouri may collaborate with local partners to determine when an alert should be issued for a local area.

- **Excessive Heat Warning —** An Excessive Heat Warning is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Warning is when the maximum heat index temperature is expected to be 105° or higher for at least 2 days and nighttime air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas not used to extreme heat conditions. If you do not take precautions immediately when conditions are extreme, you may become seriously ill or even die.
- **Excessive Heat Watches —** Heat watches are issued when conditions are favorable for an Excessive Heat event in the next 24 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain.
- **Heat Advisory—** A Heat Advisory is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Advisory is when the maximum heat index temperature is expected to be 100° or higher for at least 2 days, and nighttime air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas that are not used to dangerous heat conditions. Take precautions to avoid heat illness. If you do not take precautions, you may become seriously ill or even die.
- **Excessive Heat Outlooks** are issued when the potential exists for an Excessive Heat event in the next 3-7 days. An Outlook provides information to those who need considerable lead-time to prepare for the event.

Figure 3.98. Wind Chill Chart

Wind Chill Chart

Wind (mph)	Calm 40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Temperature (°F)

Frostbite Times: 30 minutes / 10 minutes / 5 minutes

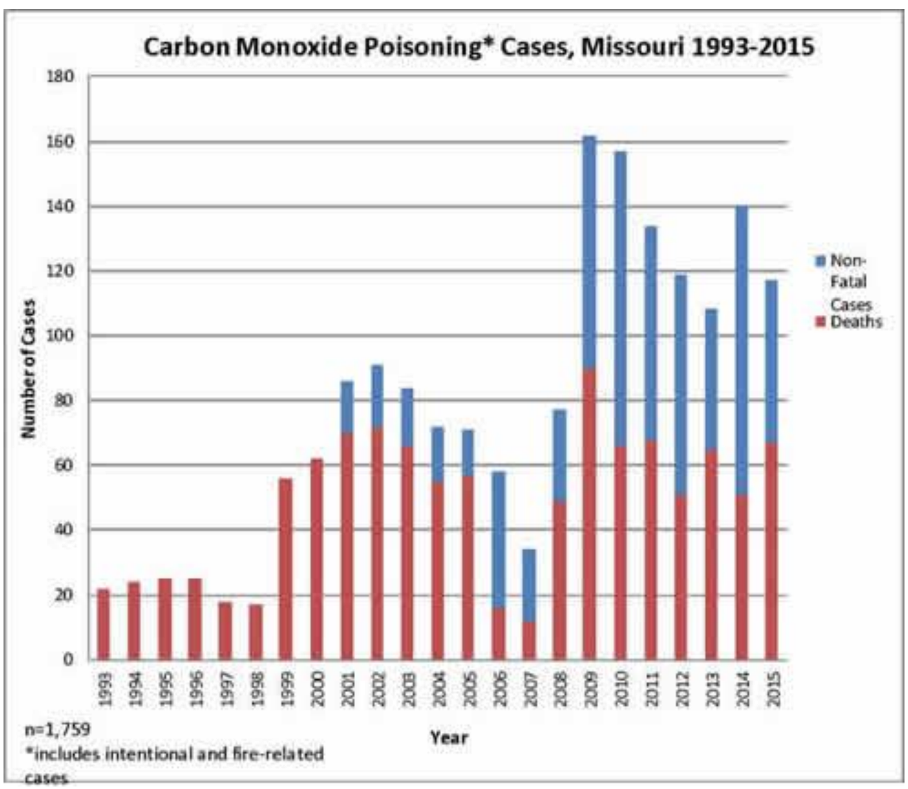
$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service; http://www.nws.noaa.gov/om/cold/wind_chill.shtml

Figure 3.99. Carbon Monoxide Poisoning Cases, Missouri, 1993-2015



Source: Missouri DHSS; https://health.mo.gov/living/environment/carbonmonoxide/index.php

Extreme Cold

The National Weather Service issues some or all of the following wind chill and frost/freeze products as conditions warrant across the State of Missouri.

- **Wind Chill Warning:** NWS issues a wind chill warning when dangerously cold wind chill values are expected or occurring. If you are in an area with a wind chill warning, avoid going outside during the coldest parts of the day. If you do go outside, dress in layers, cover exposed skin, and make sure at least one other person knows your whereabouts. Update them when you arrive safely at your destination.
- **Wind Chill Watch:** NWS issues a wind chill watch when dangerously cold wind chill values are *possible*. As with a warning, adjust your plans to avoid being outside during the coldest parts of the day. Make sure your car has at least a half a tank of gas and update your winter survival kit.
- **Wind Chill Advisory:** NWS issues a wind chill advisory when seasonably cold wind chill values, but not extremely cold values are expected or occurring. Be sure you and your loved ones dress appropriately and cover exposed skin when venturing outdoors.
- **Hard Freeze Warning:** NWS issues a hard freeze warning when temperatures are expected to drop below 28°F for an extended period of time, killing most types of commercial crops and residential plants.
- **Freeze Warning:** When temperatures are forecasted to go below 32°F for a long period of time, NWS issues a freeze warning. This temperature threshold kills some types of commercial crops and residential plants.
- **Freeze Watch**: NWS issues a freeze watch when there is a potential for significant, widespread freezing temperatures within the next 24-36 hours. A freeze watch is issued in the autumn until the end of the growing season and in the spring at the start of the growing season.
- **Frost Advisory:** A frost advisory means areas of frost are expected or occurring, posing a threat to sensitive vegetation.

For both extreme heat and extreme cold temperatures, the following population groups in Missouri are at a greater risk to injury and/or illness:

- Those vulnerable to heat stress due to physical condition:
  - Older people
  - Children
  - People overweight or underweight
  - People with limited independence due to physical or mental disorders
  - People in institutional settings without air conditioning/heat
  - People working in heat under stress (firefighters, police, emergency medical technicians)
  - People in urban environments where heat retention in asphalt, concrete, and masonry is a factor (heat island effect)
  - People with low income who lack resources for air conditioning, transportation, medical care, etc.
- Those with increased risk from work or leisure activities:
  - People who work outdoors (utility crews, construction crews, etc.)
  - Military personnel and trainees
  - Athletes

- Those more difficult to reach through normal communications:
  - People who live alone
  - People who are homeless
  - People who do not speak English
  - People who cannot read
  - People who are culturally, socially, or geographically isolated

Previous Occurrences

Missouri experiences about 40 days per year above 90 ºF, based on a 30-year average compiled by the NWS from 1961 through 1990. July leads this statewide mean with 15 days above 90°F, followed by August with an average of 12 days over 90°F. June and September average 6 days and 4 days, respectively, for temperatures above 90°F. The 30-year climatic data was collected from NWS stations at Kansas City, Columbia, Springfield, and St. Louis. As these regional locations indicate, all of Missouri is subject to heat wave during the summer months.

The Missouri Department of Health and Senior Services (DHSS) monitor high temperatures and humidity across the State to prevent heat-related illness and death. The elderly and the chronically ill are more vulnerable to the effects of high temperatures. They perspire less and are more likely to have health problems requiring medications that can impair the body's response to heat. Many prescription medications make individuals more sensitive to the heat. Some of these medications include heart drugs, some anti-Parkinsonian agents, antihistamines, over-the-counter sleeping pills, antidepressants, anti-psychotics and major tranquilizers.

DHSS initiated statewide hyperthermia death surveillance in 1980 in response to a summer heat wave that resulted in the death of 295 individuals. The program defines hyperthermia as physician-diagnosed heat exhaustion, heat stroke, or hot weather/natural environment as a contributing factor in a death. Between 1980 and 2016, 1,272 people have died from excessive heat and high humidity in Missouri. Missouri's heat-related deaths are primarily in the urban, more densely populated areas of St. Louis City, St. Louis County, and Jackson County (Kansas City). DHSS previously provided statistics on heat related emergency room visits and heat related hospitalizations for 1999 through 2010. **Table 3.53** displays a summary of this data.

Table 3.53. Heat-Related Emergency Rooms and Hospitalizations in Missouri 1999-2010

Year	Heat Emergency Room Visits	Heat Related Hospitalizations
1999	1,176	209
2000	1,356	168
2001	1,422	254
2002	1,267	217
2003	1,063	191
2004	815	114
2005	1,340	228
2006	1,377	298
2007	1,315	227
2008	957	143
2009	939	186
2010	1,772	379

Source: Missouri DHSS, https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdf

The NCEI Storm Events Database provides information on previous heat and Excessive Heat events in Missouri. **Table 3.54** lists the annual total of events, deaths, injuries, property damages, and crop damages for 1996 through 2021 for heat related events.

NCEI defines Excessive Heat as a combination of high temperatures (well above normal) and high humidity. An Excessive Heat event occurs and is reported in Storm Data whenever heat index values meet or exceed locally/regionally established Excessive Heat warning thresholds, on a widespread or localized basis. Fatalities (directly related) or major impacts to human health occurring during Excessive Heat warning conditions are reported using this event category.

Fatalities or impacts to human health occurring when conditions meet locally/regionally defined heat advisory criteria are reported within the Heat event category. If deaths are determined to be a result of the heat, but locally/regionally defined heat warning or heat advisory criteria are not met, then the fatalities can only be mentioned in the narrative of another Storm Data event that occurred near the time of death.

Table 3.54. Annual Heat Events in Missouri, 1996-2021

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	8	2	44	-	-
1997	17	3	38	-	-
1998	63	5	306	-	-
1999	150	77	397	-	-
2000	322	18	266	$125,000	$105,000
2001	478	31	213	-	-
2002	131	17	334	-	-
2003	115	12	147	-	-
2004	38	1	74	-	-
2005	96	8	158	-	-
2006	228	16	856	-	-
2007	94	13	963	-	-
2008	31	0	68	-	-
2009	65	2	130	$30,000	-
2010	280	7	276	-	-
2011	291	14	726	$400,000	-
2012	353	34	672	-	-
2013	54	2	25	-	-
2014	74	0	10	-	-
2015	150	1	92	-	-
2016	127	4	116	-	-
2017	75	2	82	-	-
2018	87	0	211	-	-

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2019	54	0	59	-	-
2020	37	0	0	-	-
2021	52	0	19	-	-
Grand Total	**3,470**	**269**	**6,282**	**$ 555,000**	**$105,000**

Significant heat events include the following:

July/August 2001: The first real heat wave of the summer hit the area July 7 through July 10. Temperatures peaked in the middle to upper 90s with the Heat Index ranging from 105 to 110. Heat returned to the region in August as high temperatures hit the middle to upper 90s with the Heat Index ranging from 102 to 110. 30 deaths occurred in 2001 from heat.

July 2002: High temperatures climbed into the middle to upper 90's with Heat Indices from 105 to 110 degrees.

July 2006: Excessive Heat returned to the St. Louis area in late July and continued into early August. The temperature at Lambert International Airport hit 101 on both the 30th and 31st with the Heat Index around 110. July 2006 was no exception to heat wave conditions in Missouri. The NWS indicated that the July temperatures following the St. Louis storm were expected to be 91-95°F within a one-week period with the heat indices expected to reach 100°F in the metro area at that time. A federal disaster declaration was received on July 21, 2006, for the City of St. Louis and surrounding counties to the west and southwest of the City. Heat wave conditions continued throughout the month of July with heat indices reaching 105–115°F by the end of the month. The storm event caused many households and businesses to be without power for an extended period of time. The power outages caused the heat wave to have a profound effect on individuals residing within the impacted area. By July 31, 2006, 10 heat-related deaths had been reported in Jefferson County, St. Louis City, and St. Louis County. July 19, 2006, after reaching a high temperature of 100 degrees, a cluster of thunderstorms, also known as a mesoscale convective system, formed across Northern Illinois and propagated southwest across West Central Illinois and Eastern Missouri. Straight line winds created widespread wind damage from Central Illinois across the St. Louis Metropolitan Area and into the Eastern Ozarks. The damage sustained in the St. Louis Metropolitan Area was consistent with wind speeds between 70 and 90 mph. Two tornado tracks were also uncovered across Southwest Illinois near the towns of Bunker Hill and Edwardsville. Over 500,000 customers were left without power, and thus no air conditioning. A State of Emergency was declared for the St. Louis Area, and the National Guard was called in to help with heat evacuations. The temperature rose near 100 degrees once again on Thursday and heat index values were as high as 115 degrees in the affected region. (NWS MO) The power outages caused the heat wave to have a profound effect on individuals residing within the impacted area (CNN, 2006). By July 31, 2006, 10 heat-related deaths had been reported in Jefferson County, St. Louis City, and St. Louis County. This incident accounted for nearly half of the total 25 heat-related deaths that occurred in Missouri in 2006 (Missouri DHSS, 2011).

August 2007: The first and only Heat Wave of the summer started on August 4th and lasted through August 16th. Eight deaths were reported in the St. Louis Metro area. The city of St. Louis reported 422 heat related injuries. St. Louis County reported 519 heat related injuries. At least 450 people were

injured at an outdoor concert held on August 6th, and another 50 were injured at another outdoor concert on the 14th. Many schools across the region went to an early dismissal schedule to combat the heat. St. Louis hit 100 degrees on the 7th and 8th, 102 on the 12th, 103 on the 14th, and 105 on the 15th. The highs on the 14th and 15th set new records. Columbia hit 100 or higher on six days and set a new record of 103 degrees on the 16th. August 2007 ended up being the 3rd warmest on record for St. Louis and the 4th warmest on record for Columbia. The Department of Health and Senior Services reported at least 1300 heat related injuries across the state.

July 2011: A major Heat Wave started on July 17th and continued into August. High temperatures ranged from the lower 90s to around 100. Columbia hit 100 on July 28 while St. Louis topped the century mark on six days, including four in a row from July 20 - 23. Low temperatures at night were generally around 80. The Heat Index ranged from around 105 to 110. There were five deaths reported in the City of St. Louis with three in St. Louis County. Over 100 people were treated at a U2 concert held at Busch Stadium the evening of the 17th.

June 2012: Some of the hottest temperatures in many years occurred the last 4 days of June and continued into July. St. Louis, MO recorded its highest ever June temperature hitting 108 degrees on June 28. Nearly all reporting stations were over 100 degrees the last 3 to 4 days of June with most sites around 105. The 28th was the hottest day. Some high temperatures across the Missouri counties on the 28th included 109 degrees at Spirit of St. Louis Airport in Chesterfield, 108 in Farmington and Fredericktown, 107 in Washington, Columbia, and Jefferson City, and 106 in Warrenton. The good thing was the air was very dry, thus the Heat Index was not much different than the air temperature. The City of St. Louis reported two heat related deaths on June 30. St. Louis County reported 20 heat related injuries on June 29, and 23 on June 30. The City of St. Louis reported 2 heat related deaths on June 30. An 80-year-old man died in his home. There was a window air conditioner, but it was not turned on. A 74-year-old woman was found dead in her apartment. There was central air conditioning that was not turned on.

July 2017: An excessive heat wave came through central and east central Missouri in mid-July. High temperatures ranged from the upper 90s to a high in St. Louis on July 22 of 108 degrees. The heat index ranged from 105 to around 110. The St. Louis County Health Department reported 51 heat related illnesses.

July 2018: Several days of oppressive heat and humidity were experienced across southeast Missouri, where heat indices peaked in the triple digits on five consecutive days. The highest heat indices were observed on the 14th when values from 110 to 115 were recorded along and south of a Sikeston to Poplar Bluff line. Areas north of Cape Girardeau including Perryville were impacted the least. At Perryville, heat indices peaked below 100 degrees on the 12th.

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of Excessive Heat for the 10-year period of 2012 – 2021 totaled $82,691,733. Excessive Heat ranked 5th in the State for insured crop losses. Also, hot winds in Missouri totaled $6,305,066 in insured crop losses from the same timeframe. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: https://www.rma.usda.gov/-/media/RMA/State-Profiles/2022/Missouri-2022-State-Profile.ashx?la=en.

The NCEI Storm Events Database also provides information on previous extreme cold/wind chill and frost/freeze events in Missouri. **Table 3.55** lists the annual total of events, deaths, injuries, property damages, and crop damages for 1996 through 2021 for extreme cold events.

Table 3.55. Annual Extreme Cold & Frost/Freeze Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	-	-	-	-	-
1997	11	0	0	0	$0
1998	-	-	-	-	-
1999	-	-	-	-	-
2000	166	1	0	$125,000	$105,000
2001	53	1	0	0	$0
2002	-	-	-	-	-
2003	5	0	0	0	$0
2004	-	-	-	-	-
2005	17	0	0	0	$2,645,000
2006	11	0	0	0	$0
2007	184	0	0	0	$166,323,950
2008	46	0	0	0	$220,000
2009	40	0	0	0	$0
2010	11	0	0	0	$0
2011	22	0	0	0	$0
2012	12	0	0	0	$0
2013	33	0	0	0	$0
2014	44	0	0	0	$100,000
2015	11	0	0	0	$0
2016	11	0	0	0	$0
2017	11	0	0	0	$0
2018	73	3	0	0	$5,000
2019	36	0	0	0	$0
2020	40	0	0	0	$0
2021	229	0	0	95,000	$3,500,000
Totals	**1,066**	**5**	**0**	**$220,000**	**$172,893,950**

Significant extreme cold events include the following:

December 2000: Abnormally cold air moved into the Ozarks by the middle of December as the main jet stream carved out a deep trough of low pressure over the eastern 2/3's of the nation. This pattern continued through the early part of January. The combination of deep snow cover and an abnormally strong arctic air mass kept temperatures 10 to 20 degrees below normal. The severe cold caused numerous water mains to brake, roof leakage, and hazardous roadways due to ice and snow. In Stafford, a water main broke under a new high school gymnasium causing considerable damage to the school ceiling tiles, light fixtures and the gymnasium floor. In addition, hay supplies rapidly decreased as persistent ice- and snow-covered fields. Snow cover and cold conditions also made it difficult for farmers and ranchers to feed their animals, which had an adverse effect on livestock and newly born calves. Several calves died due to the severe stress of the cold and low supply of hay, especially in southwest Missouri.

January 2001: The prolonged arctic freeze that began during the second week of December finally ended by January 4. During the first few days of the new year, temperatures averaged 15 to 25 degrees below normal. Overnight lows were in the single digits. As a result, ice continued to be a problem on the Mississippi River. The combination of ice and low river levels made navigation for barges very hazardous. About 10 miles north of Cape Girardeau, 15 barges loaded with coal went aground. Ice floes halted the ferry service between Dorena, MO and Hickman, KY until warmer weather arrived.

January 2009: In the wake of an arctic cold front, gusty northwest winds from 15 to 25 mph combined with a surge of arctic air to produce wind chills from minus 5 to minus 15 degrees.

February 2014: Cold air and north winds combined to bring wind chill values down to 30 degrees below zero.

May 2005: Record breaking cold settled over the Midwest during the early morning hours of 3 May 2005. The cold was of such intensity that all-time record minimums for the month of May were tied or shattered at most first order stations and many co-operative stations. Farmers that took advantage of the unseasonably mild weather during the first half of April had to replant after crops were killed off by the freeze. In some cases, crops had to be replanted even though the growing point was below the surface. This was due to the soil being a sandy loam which allowed freezing temperatures to penetrate into the ground.

April 2007: Unusually warm conditions during the month of March caused early season growth in vegetation across the Missouri Ozarks. Hay along with the wheat crop had begun to mature. During the nights of April 7th through the 9th, temperatures dropped into the upper teens to mid-20s, causing a hard freeze on matured vegetation. The wheat crop suffered approximately 90% damage. Hay crops along with fescue seed also sustained major damage. Total crop losses for 34 counties across the southwestern quadrant of Missouri were estimated at $147,905,541.

January 14–20, 1994: Northeast, central, and east-central Missouri experienced overnight low temperatures from below zero to –20°F. Hundreds of homes and businesses had frozen and busted water pipes. Wind chills, which ranged from -30 to -50°F, kept schools closed and accounted for 15 people being admitted to local hospitals for hypothermia and frostbite.

January 10–13, 1997: Northwest and west-central Missouri experienced overnight low temperatures below zero. No record low temperatures were recorded, but winds gusting up to 30 miles per hour produced afternoon wind chills as low as -30 to -50°F. According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of cold wet winter, cold winter, freeze, and frost conditions for the eleven-year period of 1998 – 2008 totaled $20.9 million.

April 2007: Unusually warm conditions during the month of March caused early season growth in vegetation across the Missouri Ozarks. Hay along with the wheat crop had begun to mature. During the nights of April 7th through the 9th, temperatures dropped into the upper teens to mid-20s, causing a hard freeze on matured vegetation. The wheat crop suffered approximately 90% damage. Hay crops along with fescue seed also sustained major damage. Total crop losses for 34 counties across the southwestern quadrant of Missouri were estimated at $147,905,541.

April 2018: For the second consecutive morning, low temperatures fell below freezing. Lows ranged from the lower 20's in Wayne, Bollinger, and Perry Counties to the lower 30's from Poplar Bluff east to Sikeston and New Madrid. The back-to-back freezes adversely impacted fruit crops and some flowering

plants and shrubs. The high pressure that brought the cold weather was centered over the middle and upper Mississippi Valley.

February 2021: An extended period of unseasonably cold weather gripped central and southwest Missouri between February 7 and February 18. Record to near record low temperatures were common with subzero lows and highs just in the single digits and teens above zero. In addition, wind chill readings between -20 and -30 were reported across the area. This created widespread snow-covered roads and the cold and snow combined resulted in numerous if not all schools being closed. The city of Marionville reported water line breaks in the court building and sewer plant as well as numerous potholes in city streets.

April 2021: A late season cold snap brought freezing temperatures down into the 20s to southern and Central Missouri on both the mornings of April 21 and April 22. As a result of an unusually warm period in green up and bloom of area fruit trees and early emergence of specialty crops such as strawberries, grapes, blueberries, pawpaws, peaches, apples, walnuts and pecans, varying degrees of damage and bloom kill from the frost and hard freeze occurred. Information provided by University of Missouri Extension, USDA and FSA agents indicated that in some areas, losses of some of the specialty crops were as high as 90 percent or more, while others suffered little or not at all. Across southwestern Missouri, reports were received of losses to peaches of 75 percent or more and apples of 50 percent or greater in Webster County. In Phelps County, a vineyard reported a loss of 90 percent or more of their crop. A report from Barry County indicated that pecans and walnuts saw a nearly 50 percent reduction due to the freeze.

Probability of Future Hazard Events

With a total of 3,470 extreme heat events from 1996 to December 2021 there are an average of 133 events per year. There are 1,066 recorded extreme cold events with an average of 41 events per year. Missourians have a very high probability that extreme temperature events will continue to occur each year. **Figure 3.100** and **Figure 3.101** present the average annual occurrence for extreme heat and extreme cold, respectively, within each county.

Figure 3.100. Average Annual Occurrence for Extreme Heat

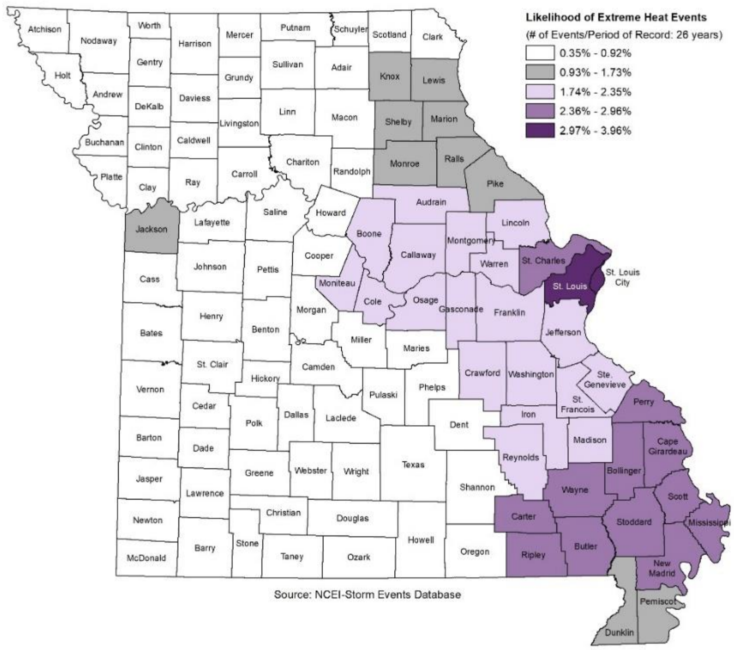
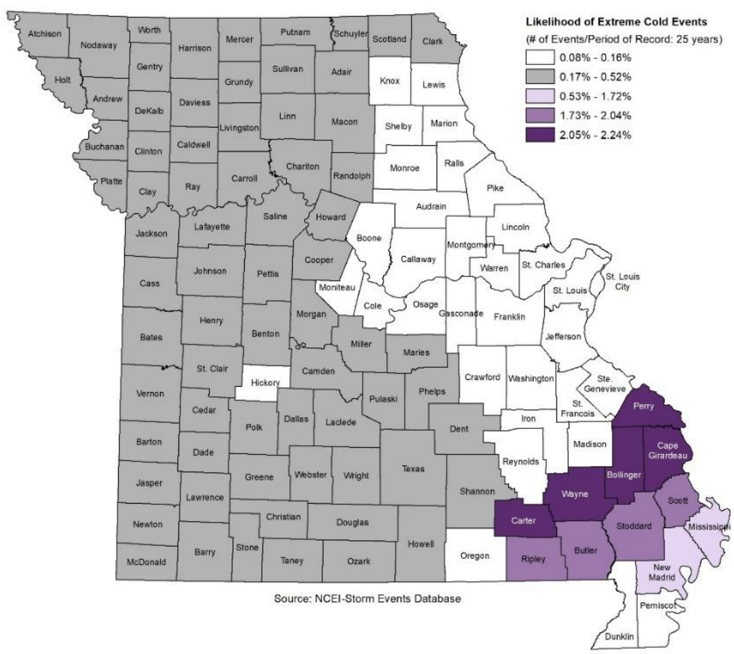


Figure 3.101. Average Annual Occurrence for Extreme Cold



Changing Future Conditions Considerations

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the century. Even under a pathway of lower greenhouse gas emissions, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. For example, in southern Missouri, the annual maximum number of consecutive days with temperatures exceeding 95

degrees F is projected to increase by up to 20 days. Temperature increases will cause future heat waves to be more intense, a concern for this region which already experiences hot and humid conditions. Extreme heat is a concern for urban areas such as St. Louis and Kansas City, where the urban heat island effect raises summer temperatures. If the warming trend conditions, future heat waves are likely to be more intense, and cold wave intensity is projected to decrease.

The impacts of extreme heat events are experienced most acutely by the elderly and other vulnerable populations. High temperatures are exacerbated in urban environments, a phenomenon known as the urban heat island effect, which in turn tend to have higher concentrations of vulnerable populations. Higher demand for electricity as people try to keep cool amplifies stress on power systems and may lead to an increase in the number of power outages. Atmospheric concentrations of ozone occur at higher air temperatures, resulting in poorer air quality, while harmful algal blooms flourish in warmer water temperatures, resulting in poorer water quality.

Mitigation against the impacts of future temperature increase may include increasing education on heat stress prevention, organizing cooling centers, allocating additional funding to repair and maintain roads damaged by buckling and potholes, and reducing nutrient runoff that contributes to algal blooms. Local governments should also prepare for increased demand on public recreational facilities, utility systems, and healthcare centers. Improving energy efficiency in public buildings will also present an increasingly valuable savings potential.

State Vulnerability Overview

Extreme heat and extreme cold events are common occurrences in Missouri. The method used to determine vulnerability to extreme temperatures across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2021), total population and percentage of population over 65 data from the U.S. Census (2019), and the calculated Social Vulnerability Index for Missouri counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

From the statistical data collected, four factors were considered in determining overall vulnerability to extreme temperatures as follows: total population, percentage of population over 65, likelihood of occurrence, and social vulnerability. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. Once the individual ratings were determined for the above factors, a combined vulnerability rating was computed for extreme heat and extreme cold. These rating values correspond to the following descriptive terms:

1) Low
2) Medium-Low
3) Medium
4) Medium-High
5) High

All county-level statistical data tables, including ranges for vulnerability factor ratings, are presented in Appendix A. **Figure 3.102** and **Figure 3.103** present the vulnerability summary for extreme heat and extreme cold temperatures, respectively.

Figure 3.102. Vulnerability Summary for Extreme Heat

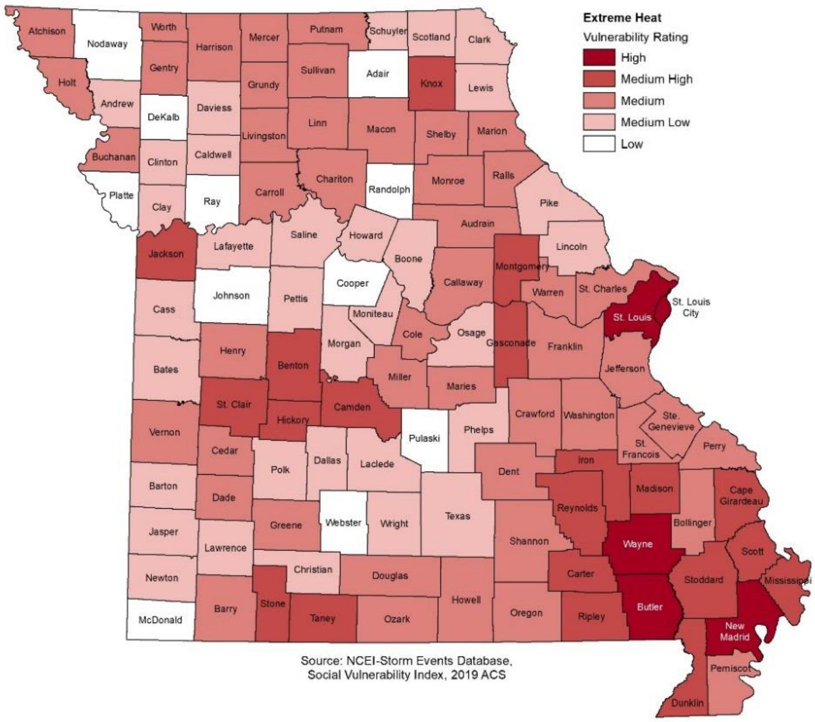
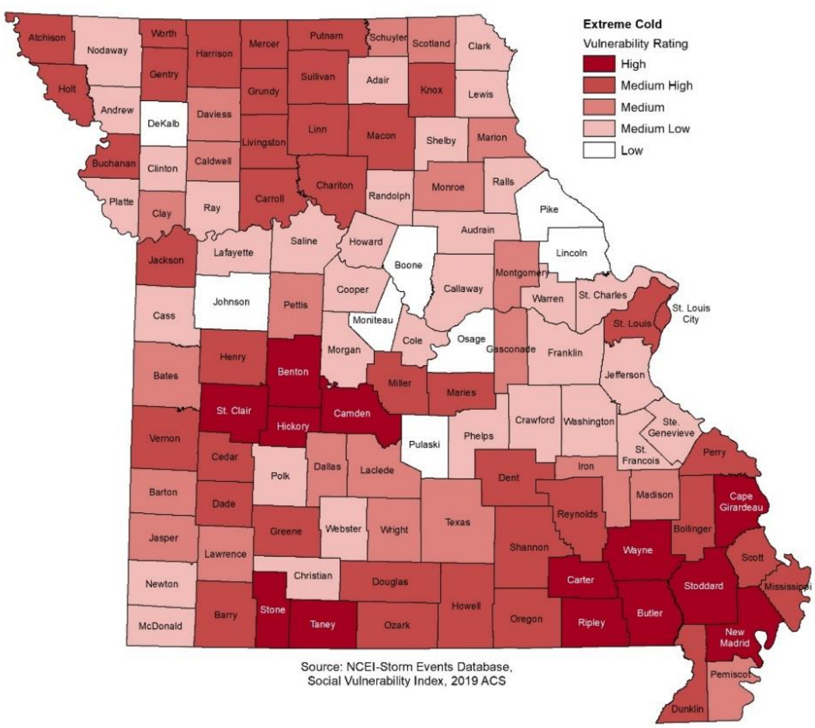


Figure 3.103. Vulnerability Summary for Extreme Cold



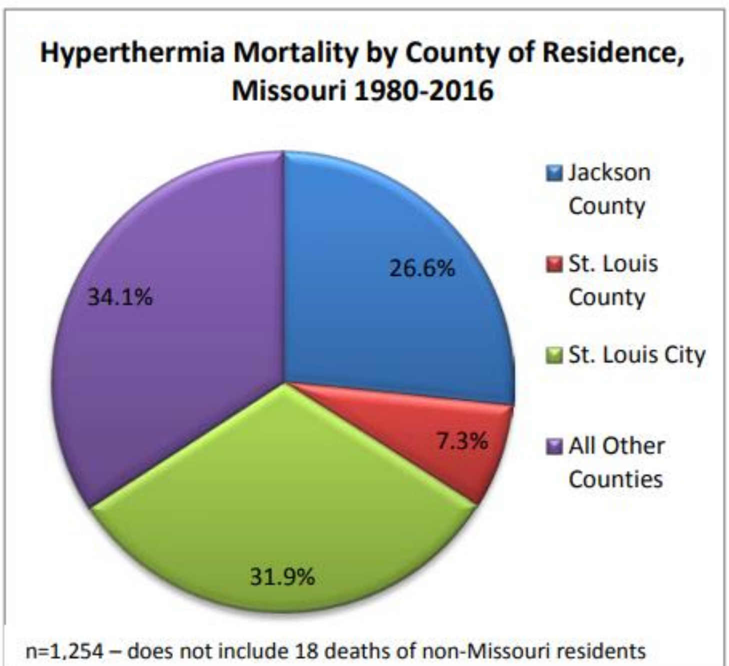
Extreme Heat/Heat Wave

The Missouri Department of Health and Senior Services reports: "In Missouri, the greatest numbers of heat-related deaths have occurred in the urban, more densely populated areas of St. Louis City, St Louis County and Jackson County (Kansas City). Of the 1,272 heat-related deaths reported from 1980 through 2016, there were 826 (64.9%) deaths in these metropolitan areas. Rural deaths accounted for 428 (33.6%) of the deaths. Non-Missouri residents who succumb to heat while visiting are considered cases, accounting for 18 deaths."

Of the 1,272 hyperthermia deaths from 1980 through 2016, over half, 793 (62.3%), have been of people age 65 years and older. Victims in this population often live alone and have other complicating medical conditions. Also, lack of air conditioning or refusal to use it for fear of higher utility expenses contributes to the number of deaths in the senior population. 450 (35.4%) hyperthermia deaths occurred from people 5-years old to 64-years old. Heat-related deaths often have contributing causes such as physical activity (sports or work), complicating medical conditions, or substance abuse. Circumstances causing hyperthermia deaths in young children often involve a motor vehicle—a child left in or climbing into a parked vehicle during hot weather. From 1980-2016, there were 29 (2.3%) heat-related deaths of children less than five years of age.

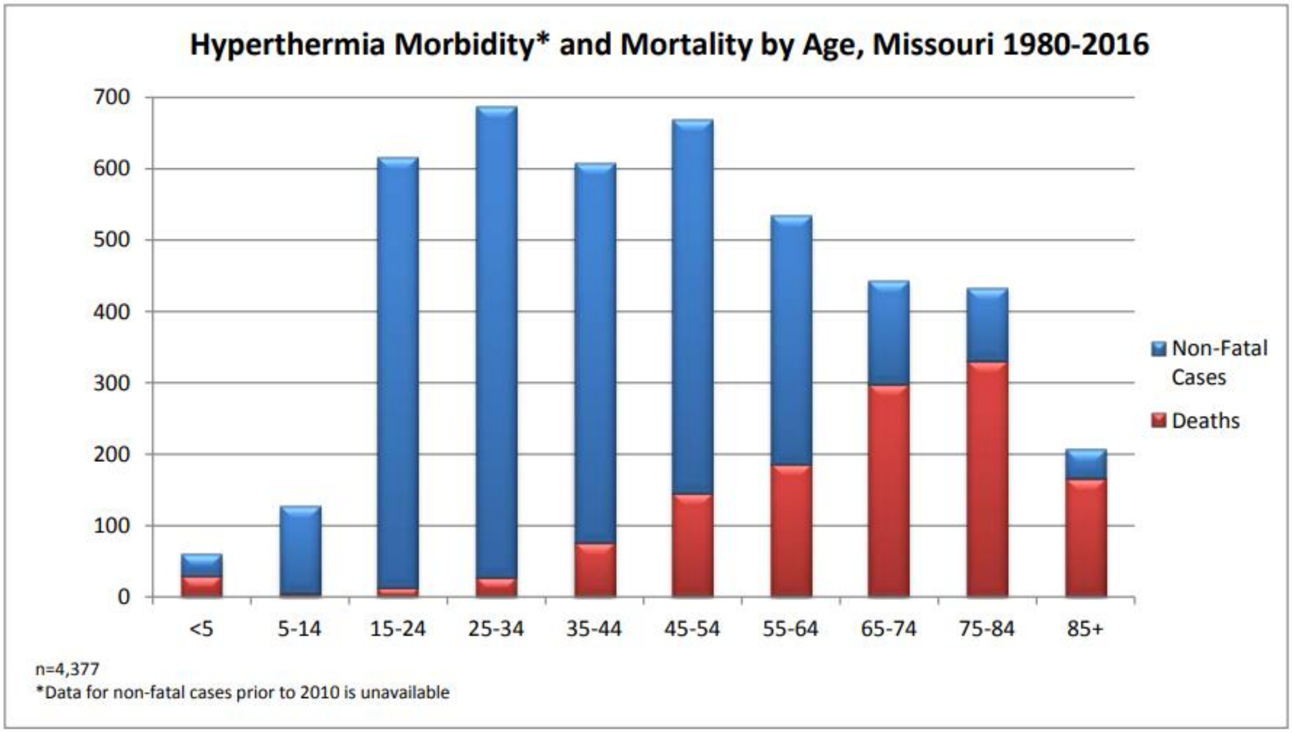
Figure 3.104 through **Figure 3.106**, prepared by DHSS, present specific populations that are vulnerable to hyperthermia according to previous occurrences:

Figure 3.104. Hyperthermia Mortality by Geographic Area, Missouri 1980-2016



Source: Missouri DHSS, https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdf
http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper2.pdf

Figure 3.105. Hyperthermia Morbidity and Mortality by Age, Missouri 1980-2016

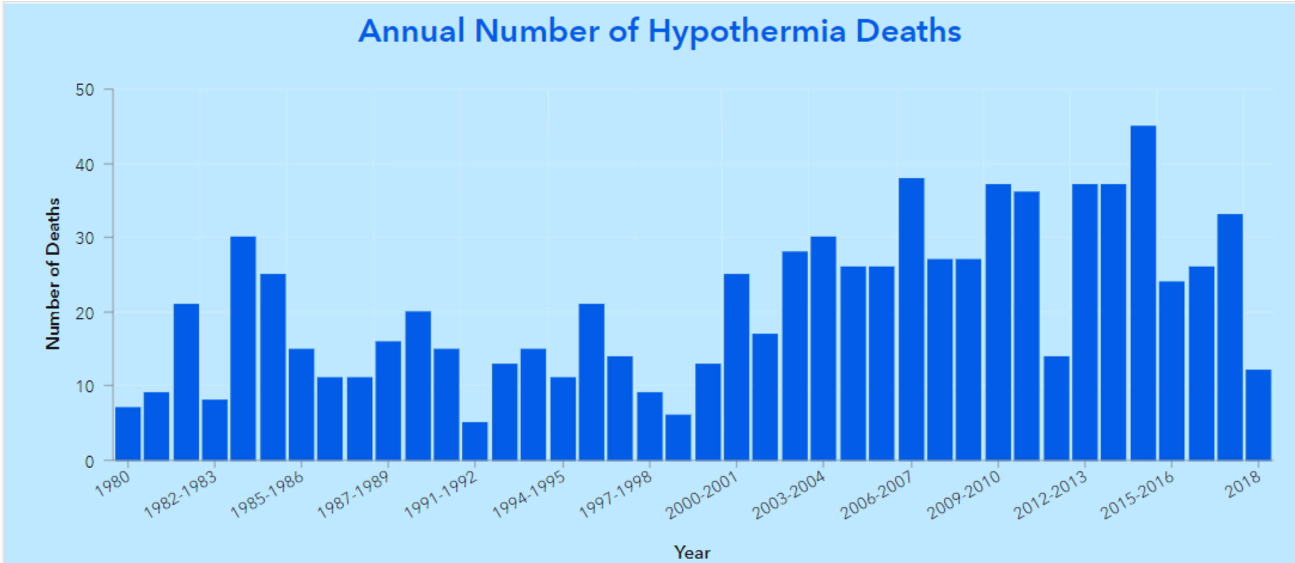


Source: Missouri DHSS, https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdfhttp://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper4.pdf

Extreme Cold

Data from the Missouri Department of Health and Senior Services shows that, in Missouri, 840 people have died from the cold during the winter months between 1980 and 2018 (see **Figure 3.106**). Data collection of hypothermia first began in Missouri in 1979.

Figure 3.106. Hypothermia Deaths, Missouri: Winter Seasons 1980–2018



Source: Missouri DHSS, https://storymaps.arcgis.com/stories/5b575e3a854245ada5ce8ee812a8079c

The elderly are more likely to be victims of cold-related illness resulting in death. Too often, handicapped or elderly individuals fall outside their homes and are unable to reach shelter or help. During the cold weather seasons 1980–2018, a total of 840 hypothermia deaths have occurred, and approximately half of hypothermia deaths were of people aged 65 years and older. Substance abuse is often a contributing cause in hypothermia deaths of individuals between the ages of 20-64. From 1980 through 2018, substance abuse (alcohol and drug use) was a factor in 241 of the 502 (48%) deaths in this age group. Fortunately, deaths in people under 25-years are rare, accounting for only 13 (2.6%) of the total hypothermia deaths during this time frame. There have been five (0.99%) deaths in children less than nine years of age.

In Missouri, slightly more deaths have occurred in the more rural areas of the State than in the metropolitan areas. Jackson County, St. Louis County and St. Louis City accounted for 39.9% (335) of deaths with 60% (505) occurring in other areas of Missouri.

Hazard Impact on Future Growth and Development

The three counties rated “High” in overall vulnerability to extreme heat include Butler, New Madrid, and Wayne, and also the City of St. Louis. There were 13 counties that rated “High” in overall vulnerability to extreme cold: Benton, Butler, Camden, Cape Girardeau, Carter, Hickory, New Madrid, Ripley, St. Clair, Stoddard, Stone, Taney, and Wayne. Of these counties, Benton, Camden, Cape Girardeau and Taney Counties are also experiencing population gains. With growing population and increased development, there is potential for increased losses because of the increase in exposure. Also, as the population above 65 years increases, counties will experience greater hyperthermia and hypothermia deaths in Missouri when extreme temperatures occur.

Risk Summary

Many people do not realize how deadly a heat wave can be. In contrast to the visible, destructive, and violent nature of floods, hurricanes, and tornadoes, a heat wave is a "silent killer." Citizens of Missouri should be instructed to be aware of the warning signs of heat-related illness, such as light-headedness, mild nausea or confusion, sleepiness, or profuse sweating. Precautions include:

- Stay indoors as much as possible and limit exposure to the sun.
- Stay on the lowest floor out of the sunshine if air conditioning is not available.
- Consider spending the warmest part of the day in public buildings such as libraries, schools, movie theaters, shopping malls, and other community facilities. Circulating air can cool the body by increasing the evaporation rate of perspiration. Call 211 for the nearest location of a cooling center.
- Eat light, well-balanced meals at regular intervals. Avoid using salt tablets unless directed to do so by a physician.
- Drink plenty of water. Individuals with epilepsy or heart, kidney, or liver disease, who are on fluid-restricted diets, or who have problems with fluid retention should consult a doctor before increasing liquid intake.
- Limit intake of alcoholic beverages.
- Dress in loose-fitting, lightweight, and light-colored clothes that cover as much skin as possible.
- Protect your face and head by wearing a wide-brimmed hat. Wear sunscreen.
- Check on family, friends, and neighbors who do not have air conditioning and who spend much of their time alone.
- Never leave children or pets alone in closed vehicles.
- Avoid strenuous work during the warmest part of the day; use the buddy system when working in extreme heat; and take frequent breaks.

Although fans are less inexpensive to operate, they may not be effective, and may even be harmful when temperatures are very high. As the air temperature rises, airflow is increasingly ineffective in cooling the body until finally, at temperatures above 100°F (the exact number varies with the humidity); increasing air movement actually increases heat stress. More specifically, when the temperature of the air rises to about 100°F, the fan may be delivering overheated air to the skin at a rate that exceeds the capacity of the body to get rid of this heat, even with sweating, and the net effect is to add heat rather than to cool the body. An air conditioner, if one is available, is a much better alternative. More information on heat-related illness is available through the DHSS web page at http://health.mo.gov/living/healthcondiseases/hyperthermia/.

Extreme cold can also be life threatening. In order to avoid injury or death due to hypothermia, the following precautions may be taken:

- Call 911 for immediate medical assistance
- Gently move the victim to a warm place
- Monitor the victim's blood pressure and breathing
- If needed, give rescue breathing and CPR
- Remove wet clothing

- Dry off the victim
- Take the victim’s temperature
- Warm the body core first, NOT the extremities. Warming the extremities first can cause shock.
- It can also drive cold blood toward the heart and lead to heart failure.
- Do not warm the victim too fast. Rapid warming may cause heart arrhythmias

Problem Statement:

Using vulnerability for extreme heat as a key indicator, the county with the greatest percentage of vulnerable populations is Wayne (24.3%). Mitigation resources allocated for extreme heat temperatures to these two counties would be the most beneficial. Using the vulnerability for extreme cold as a key indicator, the counties with the greatest percentage of vulnerable populations are Benton (31.2%), Camden (28.9%), St. Clair (27.6), and Wayne (24.3%). Mitigation resources for extreme cold temperatures allocated to these two counties would be the most beneficial.

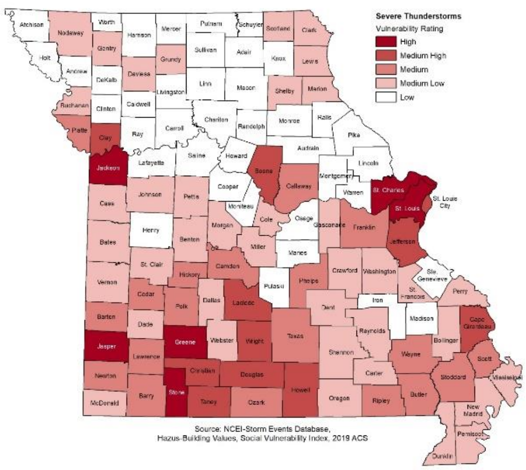
2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.8. Severe Thunderstorms (includes damaging winds, hail, and lightning)

Description

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. The National Weather Service defines a thunderstorm as severe if it contains hail that is one inch or the wind gusts are at 58 mph or higher. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time.

Vulnerability – Severe Thunderstorms



Extent/Range of Intensity

The entire State of Missouri is at risk to the damaging effects of Severe Thunderstorms. A severe thunderstorm can produce winds that can cause as much damage as a weak tornado and these winds can be life threatening. Hail associated with thunderstorms can be three quarters of an inch or more in diameter and fall at speeds more than 100 mph. ll thunderstorms produce lightning which often strikes outside of the area where it is raining and is known to fall more than 10 miles away from the rainfall area.

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

Possible impacts include risk to life and property in both the public and private sectors. Public utilities and manufactured housing developments will be especially prone to damages. Jurisdictions already affected should prioritize mitigation actions such as construction of safe rooms for vulnerable populations, retrofitting and/or hardening existing structures, improving warning systems and public education, and reinforcing utilities and additional critical infrastructure. The five counties that rated “High” in overall vulnerability to Severe Thunderstorms include Greene, Jackson, Jasper, St. Charles, St. Louis, and Stone Counties.

Changing Future Conditions Considerations

Predicted increases in temperature could help create atmospheric conditions that are fertile breeding grounds for severe thunderstorms and tornadoes in Missouri. NASA’s Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. Possible impacts include an increased risk to life and property in both the public and private sectors.

Risk Summary/Problem Statement

Severe thunderstorms losses are usually attributed to associated hazards of hail, downburst winds, lightning and heavy rains. Losses to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside the State capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are accounted for in the riverine flooding profile.

Description/Location

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When the upper air which is cold sinks and the warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, in clusters or in lines. The National Weather Service defines a thunderstorm as severe if it contains hail that is one inch or the wind gusts are at 58 mph or higher (Note: the classification for hail size indicating a thunderstorm as severe was three-fourths of an inch during development of this plan. Therefore, that size range is utilized in the risk assessment.). At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time. The entire State of Missouri is at risk to the damaging effects of Severe Thunderstorms. Other hazards associated with thunderstorms include: heavy rains causing flash flooding (discussed separately in Section 3.1), tornadoes (discussed separately in Section 3.4), damaging winds, hail, and lightning. This section of the risk assessment will focus on the damaging winds, hail, and lightning aspects of severe thunderstorms.

Damaging Winds

A severe thunderstorm can produce winds that can cause as much damage as a weak tornado and these winds can be life threatening. The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

Hail

Severe thunderstorms can produce hail that can be three quarters of an inch or more in diameter and fall at speeds more than 100 mph. Hailstones of this size cause more than $1 billion in damages to properties and crops nationwide annually. Large hail can reach the size of grapefruit.

Lightning

Lightning—All thunderstorms produce lightning which often strikes outside of the area where it is raining and is known to fall more than 10 miles away from the rainfall area. Nationwide, lightning causes an average of 55 to 60 fatalities and 400 injuries each year.

Extent /Range of Intensity

Thunderstorms can occur anywhere across the state, the extent of damaging winds, hail, and lightning are measured by the following scales.

Damaging Winds

High wind is measured by the National Weather Service to define when an advisory is necessary. The High Wind definitions are listed below. For data collection and vulnerability analyses, the threshold of 40 mph was utilized.

- **High Wind** - Sustained wind speeds of 40 mph or greater lasting for 1 hour or longer, or winds of 58 mph or greater for any duration.
- **High Wind Advisory** - This product is issued by the National Weather Service when high wind speeds may pose a hazard. The criteria for this advisory varies from state to state. In Michigan, the criteria is sustained non-convective (not related to thunderstorms) winds greater than or equal to 30 mph lasting for one hour or longer, or winds greater than or equal to 45 mph for any duration.
- **High Wind Warning -** This product is issued by the National Weather Service when high wind speeds may pose a hazard or is life threatening. The criteria for this warning varies from state to state. In Michigan, the criteria is sustained non-convective (not related to thunderstorms) winds greater than or equal to 40 mph lasting for one hour or longer, or winds greater than or equal to 58 mph for any duration.
- **High Wind Watch** - This product is issued by the National Weather Service when there is the potential of high wind speeds developing that may pose a hazard or is life threatening. The criteria for this watch varies from state to state. In Michigan, the criteria is the potential for sustained non-convective (not related to thunderstorms) winds greater than or equal to 40 mph and/or gusts greater than or equal to 58 mph.

Hail

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. The table below indicates the hailstone measurements utilized by the National Weather Service.

Table 3.56. Hailstone Measurements

Average Diameter	Corresponding Household Object
0.25 inch	Pea
0.5 inch	Marble, Mothball
0.75 inch	Penny
0.88 inch	Nickel
1.00 inch	Quarter
1.25 inch	Half dollar
1.5 inch	Walnut, Ping-pong ball
1.75 inch	Golf-Ball
2.00 inch	Hen Egg
2.50 inch	Tennis Ball
2.75 inch	Baseball
3.00 inch	Teacup
4.00 inch	Softball
4.5 inch	Grapefruit

Source: National Weather Service, http://www.spc.noaa.gov/misc/tables/hailsize.htm

Lightning

Lightning is measured by the Lightning Activity Level (LAL) scale, created by the National Weather Service to define lightning activity into a specific categorical scale. The LAL is a common parameter that is part of fire weather forecasts nationwide. The LAL is reproduced below and the planning area is susceptible to all levels:

Table 3.57. Lightning Activity Level Scale

Level	Description
LAL 1	No thunderstorms
LAL 2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five-minute period
LAL 3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a five-minute period.
LAL 4	Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a five-minute period.
LAL 5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a five-minute period.
LAL 6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag warning.

Previous Occurrences

Damaging Winds

From January 1996 to December 2021, Missouri experienced 13,369 high wind events with damaging winds in excess of 40 mph. The table below provides annual statistics from 1996 to 2021 for events 40 miles per hour or greater.

Table 3.58. Annual High Wind Events in Missouri, 1996-2016

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	330	4	27	$17,521,510	$0
1997	256	0	11	$3,074,000	$5,000
1998	442	0	7	$ 2,587,000	$50,000
1999	337	0	11	$5,311,000	$0
2000	612	0	6	$7,304,000	$55,000
2001	560	0	37	$9,242,000	$0
2002	447	0	1	$3,877,500	$200,000
2003	529	1	10	$1,560,500	$4,850,000
2004	468	2	50	$2,924,500	$7,000
2005	652	0	5	$2,978,000	$15,500
2006	638	2	44	$4,080,600	$0
2007	357	0	3	$1,789,500	$765,000

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2008	723	0	23	$60,278,850	$27,000,000
2009	519	2	8	$144,452,100	$0
2010	584	0	7	$1,996,200	$0
2011	733	1	12	$6,514,250	$105,000
2012	481	2	108	$2,903,000	$0
2013	402	0	13	$2,879,750	$0
2014	469	0	12	$2,456,500	$0
2015	581	1	3	$1,644,000	$0
2016	473	0	2	$3,415,500	$0
2017	677	0	12	$2,882,000	$0
2018	569	17	5	$1,956,000	$20,000
2019	683	1	7	$6,705,000	$0
2020	405	2	0	$10,943,000	$1,000,000
2021	442	1	2	$3,504,000	$0
Grand Total	**13,369**	**36**	**426**	**$314,780,260**	**$34,072,500**

Source: NCEI (https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=29%2CMISSOURI); *Through 12/31/2021

Some of the more notable damaging wind events are described in additional detail below:

May 1996: A Memorial Day weekend storm identified by the NWS as a microburst caused more than $10 million in damage to homes in Lee's Summit, Missouri. The storm destroyed at least 13 homes and damaged more than 100 others in several Lee's Summit subdivisions. The city also incurred a substantial cost for debris removal and cleanup activities resulting from this devastating storm.

October 2000: High winds damaged a machine shed, Morton building; farm equipment, garage, modular home, and a frame home in Carroll County.

June 2001: A mobile home was destroyed causing two injuries in Putnam County.

May 2002: Wind gusts near 90 miles per hour caused considerable damage at a marina in St. Charles County on the Mississippi River. About 75 percent of the $2 million marina was destroyed.

June 2003: A line of strong storms moved across Clark County damaging 20,000 acres of crops (17,000 acres of corn and 3,000 acres of wheat).

August 2003: Two mobile homes were destroyed causing one injury and one fatality in Cass County. A camper trailer was overturned in Henry County causing three injuries.

July 2004: Severe winds caused damage at a campground near Truman Lake where 48 people were injured. One man that was driving his boat on the lake was killed. Other damages reported were to 35 homes and businesses.

July 2005: Intense straight-line winds downed several trees in Laclede County and a few homes sustained structural damage. A roof was blown off of a large lumber yard and young boy was injured when a tree fell into his home.

March 2006: Four people were treated at a local hospital for minor injuries when their mobile home was destroyed near Portageville in New Madrid County.

April 2006: A man was killed when his mobile home was overturned in the Circle City area in Stoddard County. His son was also slightly injured. A NWS site survey indicated that straight line winds from 70 to 80 miles per hour were responsible for a path of widespread damage from Dexter east to Circle City.

July 19, 2006: Thunderstorm winds caused a partial collapse of a building that was due to be renovated in Lacledes Landing just north of the St. Louis Arch. Some of the bricks landed on the Eads Bridge causing the bridge to be temporarily closed to traffic. On the Arch grounds 120 trees were blown over and 90 others were severely damaged. At Busch Stadium, the infield tarp was torn and 30 people sustained injuries due to flying debris, including trash cans and vendor stands that were blown over within the stadium. Also, numerous trees, tree limbs, street signs and power lines were blown down throughout the City. By the time the storms moved south of the St. Louis area, an estimated 500,000 customers were without electric power.

January 2008: A powerful cold front moved rapidly southeast across southeast Missouri during the late afternoon hours. The temperature dropped 38 degrees between 4 and 8 P.M. in Cape Girardeau. An organized line of severe thunderstorms developed along the front as it crossed southeast Missouri. Widespread damaging winds accompanied the line of storms by the time they reached the Mississippi River. A couple of metal buildings were blown across fields. Approximately 20 telephone poles were snapped off.

May 2009: An intense squall line impacted extreme southeast Kansas and the Missouri Ozarks with mainly damaging winds. However, 19 tornadoes along with large hail was also observed. Due to the straight-line nature of the winds, damage was widespread and intense. Sixty to 90 mph winds created widespread damage to trees, structures, and power poles across much of the county. Roof damage to homes and businesses was significant in and around the communities of Billings, Nixa, Highlandville, and Ozark. Two mobile homes were heavily damaged in Highlandville from large trees falling on them. Several power poles were knocked over in Nixa, causing damage to some of the mobile units of the school district.

August 2009: A downburst on August 7th caused extensive damage to several businesses in a strip mall on the west side of Jefferson City; damages were estimated at $1,000,000. On August 12, downburst winds did considerable damage to a 25-block area in the southwest section of Joplin. Power lines were downed with widespread power outages and nearly 60 windows were broken at the St. Johns Regional Medical Center. Damages from this event were estimated at $500,000.

August 2011: An isolated supercell drifted towards Maryville and produced winds in excess of 80 MPH. The storm resulted in $1 Million in property damages and $100 thousand in crop damages. This storm resulted in the evacuation of the Missouri State Fairgrounds and knocked down the Missouri State Patrol's primary radio tower in St. Joseph. Luckily, there were no deaths or injuries associated with this storm.

April 2012: A supercell thunderstorm arrived between 3:40 and 3:50 PM causing localized damage near Busch Stadium. Winds up to 60 MPH collapsed a tent at a sports bar near the stadium, resulting in 100 injuries and one death.

January 2013: A line of thunderstorms intensified as it moved east across southeast Missouri. The storms increased as they moved into slightly more unstable air associated with a strengthening low level

jet. The storms were aided by the approach of a strong upper-level trough. Despite weak instability, winds of 90 knots in the lowest 3 kilometers coupled with extreme shear values resulted in damaging winds and isolated tornadoes with the strongest storms. Ahead of the thunderstorms, strong southerly gradient winds gusted up to 45 mph, mainly in the Cape Girardeau to Sikeston area.

April 2015: Damage at Spirit of St. Louis Airport was caused by a microburst, most likely near the end of runway 26R. The microburst began around 716 pm and likely ended shortly thereafter around 720 pm. There was heavy damage to a building about 440 yards from the end of runway 26R. The wind was estimated at up to 120 mph when it hit the building. A small garage door was blown off its track and the wind entered the building through this space. The wind peeled off the roof and compromised the structure of a second garage. The roof of this second garage mostly collapsed into the building. Roof materials were thrown as much as 150 yards from the building, including air conditioning units. The damage pattern was clearly divergent which lends to the microburst identification. Scattered minor tree, sign and roof damage was noted on the northern periphery of the microburst. Estimated wind speeds ranged from 65 to 90 mph.

May 2016: As a warm front lifted north through the forecast area, thunderstorms developed. Some of the storms became severe with numerous reports of large hail, some damaging winds and an EF2 tornado that occurred near Bourbon and Sullivan Missouri during the evening. The most costly damage occurred from a pair of supercells that dropped baseball to softball size hail across St. Charles County Missouri and produced severe wind gusts in St. Louis County and the City of St. Louis around the lunch hour. There were also a few reports of flash flooding with these storms. Several downed trees damaged homes and blocked roads.

November 2018: Severe thunderstorms and tornadoes developed within a Quasi-Linear Convective System that moved across the region during the late evening of November 30th and continued into the early morning of the 1st. The parent storm system intensified over the southern Plains and tracked northeast into northern Missouri. Widespread severe wind gusts between 60 and 80 mph, hail and isolated tornadoes occurred. Seven tornadoes were confirmed over southwest and south-central Missouri. The tornadoes were rated EF-0 to EF-1 based on NWS Storm Surveys. Unfortunately, there was one fatality that occurred in Aurora, Missouri when a tornado struck a local motel. Several houses were damages and trees were blown over.

April 2020: A large complex of strong to severe thunderstorms developed ahead of a cold front during the afternoon and evening as a dry line and cold front moved across the region and interacted with a very unstable air mass. The storms produced widespread straight-line wind damage from Columbus, Kansas to Springfield to Eminence. Multiple reports were received of trees, power lines and poles down across the county from multiple sources. Winds of 60-75 mph were reported along the gust front of a line of severe thunderstorms. The ASOS at the Joplin Airport measured a 62-mph gust. Reports were received from the cities of Joplin, Jasper, Duquesne, Diamond, Carrytown and Sarcoxie. On I-49, at the Jasper exit, a Semi-Truck was overturned though no injuries were reported.

July 2021: Intense thunderstorms developed rapidly along a warm front draped from northwest to southeast across the area. There were two rounds of thunderstorms, the first being discrete, rotating storms called supercells. These supercell thunderstorms dropped large hail across portions of western Illinois (Mt. Sterling area) and also across the western St. Louis metro area. Hail in excess of 2 inches was noted in both of these supercells. This line of storms contained damaging, sometimes destructive winds as they quickly pushed southeast across east-central Missouri into southwest Illinois. The worst damage

was noted from Rensselaer, MO southward to Perry, MO, where straight-line winds of 90 mph were found. This same line of storms also affected the St. Louis metro area, bringing widespread 60-70 mph winds across the metro causing many large tree limbs to fall and many to be without power.

Hail

From January 1996 to December 2021, Missouri experienced 14,475 hail events with hail larger than 0.75 inches in diameter. The table below provides annual statistics from 1996 to 2021.

Table 3.59. Annual Hail Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	443	0	0	$266,350	$0
1997	270	0	0	$1,728,750	$510,000
1998	509	0	0	$376,780	$0
1999	254	0	0	$6,954,000	$0
2000	496	0	0	$2,076,930	$0
2001	632	0	0	$1,051,747,200	$0
2002	549	0	1	$296,650	$100,000
2003	1281	0	0	$18,550,710	$7,000
2004	680	0	0	$8,844,470	$1,026,000
2005	673	0	0	$85,130	$5,000
2006	1280	0	1	$10,088,000	$0
2007	449	0	0	$120,000	$0
2008	904	0	3	$1,957,000	$0
2009	479	0	1	$645,500	$0
2010	573	0	0	$1,271,500	$0
2011	996	0	0	$9,295,100	$0
2012	536	0	1	$300,000	$0
2013	312	0	0	$1,325,000	$0
2014	525	0	0	$335,000	$65,000
2015	467	0	0	$ 875,000	$0
2016	386	0	0	$4,175,000	$0
2017	675	0	0	$1,006,000	$0
2018	350	0	0	$54,000	$0
2019	315	0	0	$202,000	$0
2020	274	0	0	$9,932,200	$0
2021	167	0	0	$180,000	$0
Grand Total	**14,475**	**0**	**7**	**$1,132,688,270**	**$1,713,000**

Source: NCEI (https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=29%2CMISSOURI

*Through 12/31/2021

Some of the more notable damaging hail events are described in additional detail below:

April 2001: The Heavy Precipitation Supercell continued east from St. Charles County and moved into north St. Louis County. The storm will likely go down in history as one of the most damaging hailstorms ever in the area. Hail ranged from 1 to nearly 3 inches in diameter. Thousands of homes and automobiles were damaged. Some automobile dealerships lost virtually their entire inventory. At the Ford Motor Company assembly plant in Hazelwood, all vehicles (hundreds) parked outside were damaged. In Florissant, a community of close to 70,000 people, it was estimated that almost every home suffered some type of hail damage. One insurance company reported that they were working on 20,000 vehicle and 18,000 property claims while another reported 14,600 vehicle and 14,400 property claims. As of April 18, at least 40,000 insurance claims for vehicles were taken in the St. Louis area alone. At Lambert St. Louis International Airport, 22 TWA jetliners suffered minor hail damage. The Missouri Air National Guard had at least 10 fighter aircraft severely damaged.

May 2002: A severe storm left behind a path of destruction over portions of Douglas County. An airport hangar near Ava was destroyed with debris scattered over a 200-yard area on the airport property. Several homes and cars in a subdivision north of Ava endured damage from hail along with numerous trees and power lines blown down. High winds and large hail caused nearly 60 apple trees at a local orchard to be blown down southeast of Lamar. Thousands of acres of wheat and fescue were damaged by hail in a swath six mile wide that extended from southwest of Lamar, through Barton County, and into Dade County.

May 2004: This appears to be the largest hailstone ever measured officially in the state of Missouri. It was 6 inches in diameter and 16 1/2 inches in circumference. Hail did extensive damage to roofs and crops across Linn County, and the property damage total is reflective of all the hail damage reported in the county. Property damage totaled $1.5M and crop damage totaled around $1M.

February 2006: Hail up to baseball size pounded the northwest part of St. Louis County. Several automobile dealerships suffered major damage to their vehicle inventory. Many homes from Maryland Heights, to Hazelwood, to Florissant, to Spanish Lake were going to need new roofs due to the hail damage. Many private vehicles were also damaged by the hail.

May 2008: Hail up to golf ball size fell on multiple counties. Most of the large hail fell on the south part of the town of Hannibal. About 200 cars in a manufacturing company parking lot were damaged.

April 2011: April 3, 2011, was an abnormally warm day, with high temperatures in the 80s and 90s. Record high temperatures were broken in several locations. A slow-moving cold front, combined with a very strong spring storm system, produced widespread damaging thunderstorms, in the late afternoon and evening hours. Supercellular thunderstorms, developed along and ahead of the cold front, as it sank southward across the area. These thunderstorms produced extremely large hail, greater than golf balls in many areas, as well as damaging winds of 60 to 80 mph. The hardest hit areas included the southern half of the Kansas City metropolitan area, especially in the Lee's Summit area. Numerous homes had various degrees of hail damage. Later in the evening, strong straight-line winds in excess of 70 mph, produced significant damage in areas from Marshall, to Moberly, and Fayette. This hail event, left over a thousand homes in Lee's Summit with various degrees of hail damage. Damage included roofs, gutters, and siding. Automobiles at area dealerships and private automobiles also suffered numerous reports of damage. Property damage totaled around $7M.

April 2013: A long lived and long tracked high precipitation supercell produced very large and damaging hail across the area. There were reports of broken windows and damage to siding on homes. The estimated damage cost for the entire county including the city of Bolivar due to this storm will be in this event.

May 2014: Softball sized hail was reported near Crowder State Park. Power lines were also reported down in West Trenton at 5:15 PM.

April 2015: Large hail fell across Sullivan and Stanton. Most of the hail stones were between 1 and 3 inches. However, a few stones were up to 4 inches in diameter. A number of vehicles sustained major damage with broken windshields and large dents. Also, numerous homes sustained minor to moderate roof damage.

May 2016: Very large hail up to 4 inches in diameter fell across portions of St. Charles County. The hardest hit areas stretched from near Dardenne Prairie, O'Fallon and Weldon Spring east to Cottleville, St. Peters and St. Charles. Damage from this hailstorm will be many millions of dollars as thousands of homes, vehicles and businesses were impacted and suffered damage. One hundred twenty cars at a car dealership near the intersection of I-64/Highway 94, sustained busted windows and lots of dents from large hail, some that were as big as baseballs. Reports of windows blown out, roofing and siding damage were common.

March 2017: Severe thunderstorms producing numerous reports large hail along with scattered wind damage and a couple of tornadoes impacted Missouri Ozarks and southeastern Kansas. Baseball size hail were reported. Hail damaged a few cars and homes.

January 2020: During the afternoon and evening of the 10th, strong to severe thunderstorms developed ahead of a cold front over eastern Oklahoma and southeast Kansas before spreading northeast into the Missouri Ozarks. Several tornadoes rated as EF-0 and EF-1 occurred near the towns of Strafford, Fair Play and Cross Timbers, and hail up to the size of golf balls occurred on the east side of Springfield. The combination of wind and hail led to hundreds of vehicles suffering damage.

Lightning

From January 1996 to 2021, 270 damaging lightning events were reported in Missouri. There are likely thousands of lightning events that occur annually that go unreported either because damages did not occur or because the damages were not reported to be captured in NCEI statistics**. Table 3.60** provides annual statistics from 1996 to 2021 for reported lightning events in Missouri:

Table 3.60. Annual Reported Damaging Lightning Events in Missouri

Year	# of Events .75 in. or larger	Deaths	Injuries	Property Damages	Crop Damages
1996	9	1	1	$575,000	$0
1997	4	0	1	$11,000	$0
1998	6	0	2	$98,000	$0
1999	5	0	1	$73,000	$0
2000	10	0	4	$191,000	$0
2001	10	0	0	$320,000	$0
2002	14	5	1	$293,000	$0
2003	15	0	0	$17,000	$0
2004	11	0	0	$120,000	$0
2005	18	2	5	$810,000	$0
2006	12	0	2	$87,000	$2,000
2007	8	2	5	$227,000	$0
2008	18	0	17	$703,500	$0
2009	11	2	1	$164,000	$0
2010	18	1	7	$670,200	$0
2011	18	3	6	$509,000	$0
2012	3	0	4	$1,000	$14,000
2013	9	1	2	$557,000	$0
2014	8	1	1	$1,807,000	$0
2015	9	2	0	$1,151,000	$0
2016	10	1	0	$662,000	$0
2017	10	0	0	$432,000	$0
2018	14	2	1	$215,000	$0
2019	9	0	1	$238,500	$0
2020	6	1	3	$115,100	$0
2021	5	0	2	$112,000	$0
Grand Total	**270**	**24**	**67**	**$10,159,300**	**$16,000**

Source: NCEI (https://www.ncdc.noaa.gov/IPS/sd/sd.htmlx); *Through 12/31/2021

Some of the more notable damaging lightning events are described in additional detail below:

August 2002: Lightning struck four individuals who got caught in an open field during a thunderstorm and fled under a tree for shelter.

October 2005: Two men were killed and one injured by a lightning strike west of Hunnewell. The 3 men were doing road work near the bridge over the North Fork of the Salt River when the storm approached. They took shelter in a nearby shed, and when the storm appeared to let up, they headed for their vehicle. They were struck within a few feet of the vehicle. The men who died were killed instantly.

October 2008: Fourteen Buffalo High School students were injured from a large tree limb falling to the ground. This tree limb fell due to lightning striking the tree. All of the injuries from the students were minor.

May 2011: Emergency management officials relayed to the NWS that two law enforcement officers were struck by lightning while aiding in the recovery efforts from the EF-5 tornado in Joplin. Both officers were injured and taken to the hospital. One of the officers later died on June 2nd at the hospital from injuries he suffered from the lightning strike.

July 2011: A weak cool front that became stationary across the Ozarks and southeastern Kansas interacted with a very unstable airmass. Isolated strong to severe pulse storms occurred across the Ozarks which produced isolated wind damage. A small group was canoeing on the Gasconade River. As storms approached, they left the river and took shelter under a tree. Lightning struck the three, killing one on site.

August 2012: A rather strong cold front and upper-level shortwave moved across the Missouri Ozarks causing strong to severe storms to develop. These storms mainly produced damaging wind gusts and a several reports of large hail. Two people were injured from a lightning strike in Loring County. A mother and her daughter were struck by lightning in Hartville County. The bolt hit the house and traveled through a kitchen outlet. The two women were taken to a local hospital and were later released. No fire was caused by the bolt but some minor damage from the bolt was visible in the kitchen by charring around the outlet.

June 2014: Lightning struck a home on Woodmere Trail Court around 802 pm on June 21st. It smoldered for several hours. It became fully engulfed in flames by 2 am and that is when it was noticed by neighbors, and they called 911. The family that lives there was out of town for the weekend. So no injuries reported. The house was destroyed, and damage was estimated around $487,000.

May 2015: A lightning strike at the Table Rock Dam damaged two of the four hydropower generating units. These two units remained offline for about 30 days until repaired. Each turbine unit would normally generate 50,000 Mwh of electricity. Power generated at the hydro-dam was decreased by half of normal capacity.

April 2016: A lightning struck a house in Highlandville which caused a fire. The house and property inside were a total loss.

March 2017: A lightning strike started a fire at a condominium complex in Branson. Approximately 60 people were evacuated due to the fire. The fire severely damaged several condo units. There were no injuries.

September 2018: Two structures were struck by lightning. Both structures sustained damage from fires caused by the lightning strikes. No injuries were reported. Lightning also struck a large tree. Half the tree fell onto two parked cars in a driveway and the garage of the home causing major damage.

October 2021: A large hay barn was witnessed being struck by lightning. The structure was destroyed by a subsequent fire as a result of the lightning strike.

Table 3.16 in **Section 3.2.3** provides details on the Presidential Disaster Declarations in Missouri that included high winds or severe storms from 1975 to the present.

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of hail conditions for the 10-year period of 2012 – 2021 totaled $12,231,579. During this same period, insured crop losses for wind/excess wind were $15,893,749.

Probability of Future Hazard Events

Severe thunderstorm events are a common occurrence throughout Missouri. The probability has been determined to be 100% based on the NCEI data for the 26-year period from 1996-2021, resulting in the following annual average events:

- High wind - average 514 events per year
- Hail – average 556 hail events per year
- Lightning - average of 10 events per year

Severe thunderstorms and the associated wind, hail and lightning also cause deaths and injuries annually in the United States. During the 26-year period from 1996-2021, there were a combined 60 deaths and 500 injuries reported to NCEI resulting from high winds, hail, and lightning in Missouri. This translates to an annualized occurrence of 2.3 deaths and 19 injuries. With so many variables involved in death and injury occurrences, it is difficult to estimate future occurrences. However, it is noted that death and injury do occur annually in Missouri as a result of the severe thunderstorm hazard.

Figure 3.107, Figure 3.108, and **Figure 3.109** present the Average Annual occurrence for wind, hail, and lightning events in Missouri counties based on the historical events reported in the NCEI database for the period from 1996 to December 2021.

Figure 3.107. Average Annual High Wind Events (40 MPH and higher)

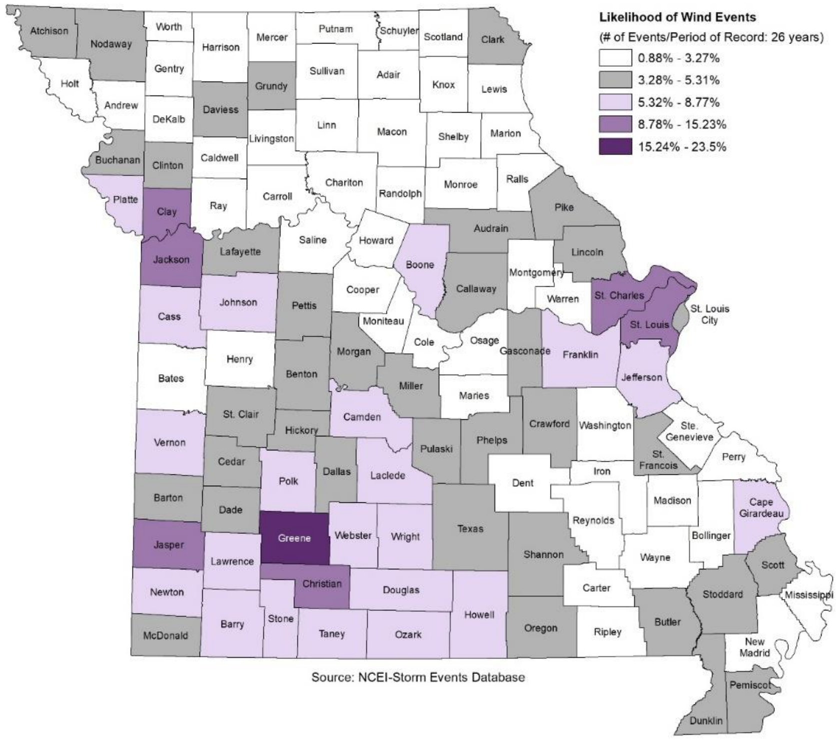


Figure 3.108. Average Annual Occurrence of Hail Events

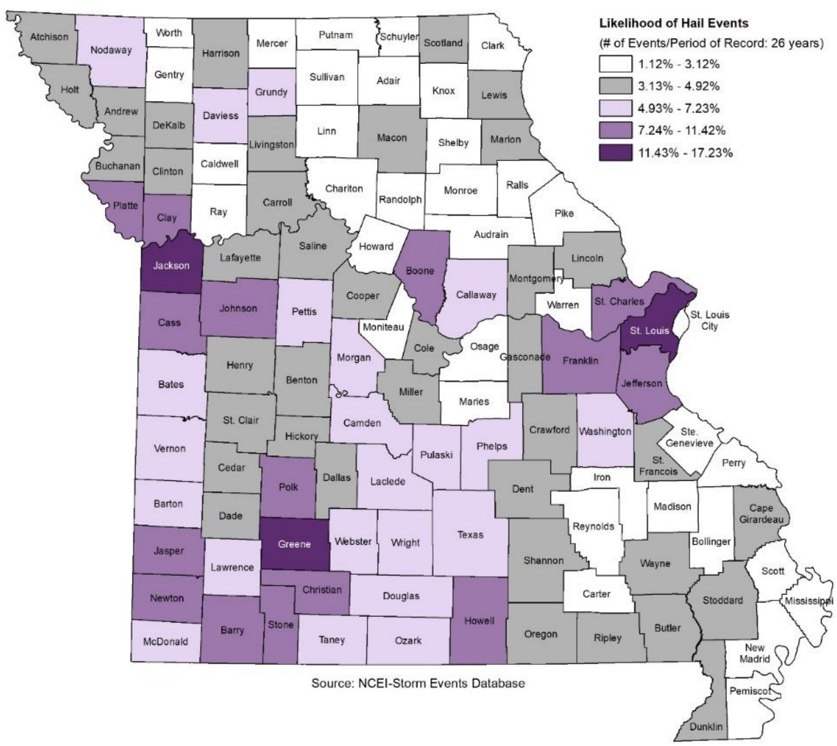
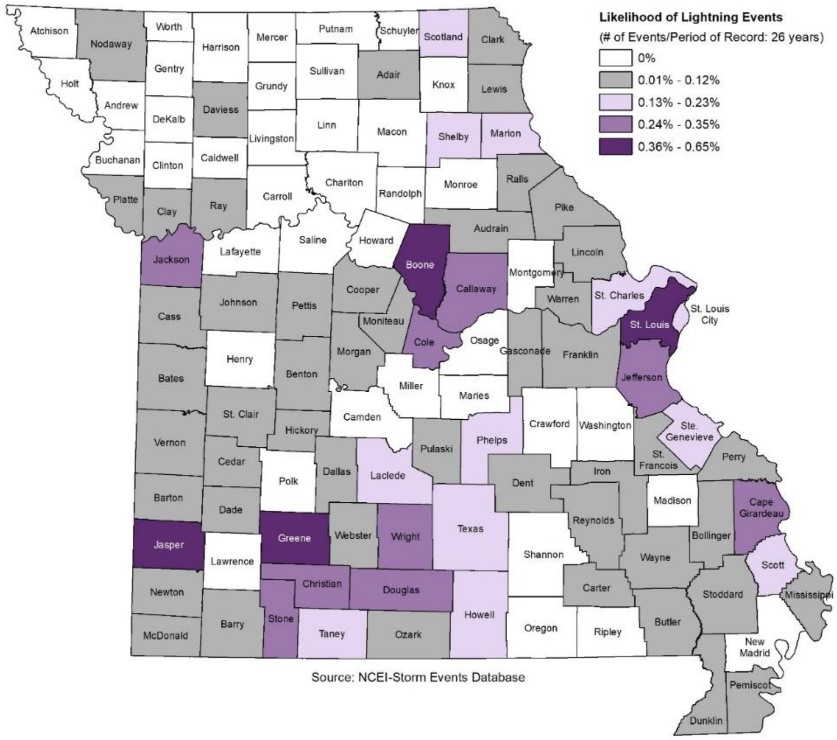


Figure 3.109. Average Annual Occurrence of Lightning Events



Changing Future Conditions Considerations

NASA’s Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. The presence of warm, moist air near the surface is a key ingredient for summer storms that meteorologists have termed “convective available potential energy,” or CAPE. With an increase in CAPE, there is greater potential for cumulus clouds to form. The study also counters this theory with the theory that warming in the Arctic could lead to less wind shear in the mid-latitude areas prone to summer storms, making the storms less likely.

Predicted increases in temperature could help create atmospheric conditions that are fertile breeding grounds for severe thunderstorms and tornadoes in Missouri. Possible impacts include an increased risk to life and property in both the public and private sectors. Public utilities and manufactured housing developments will be especially prone to damages. Jurisdictions already affected should be prepared for more of these events and should thus prioritize mitigation actions such as construction of safe rooms for vulnerable populations, retrofitting and/or hardening existing structures, improving warning systems and public education, and reinforcing utilities and additional critical infrastructure.

State Vulnerability Overview

The method used to determine vulnerability to severe thunderstorms across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2021), HAZUS Building Exposure Value data, housing density and

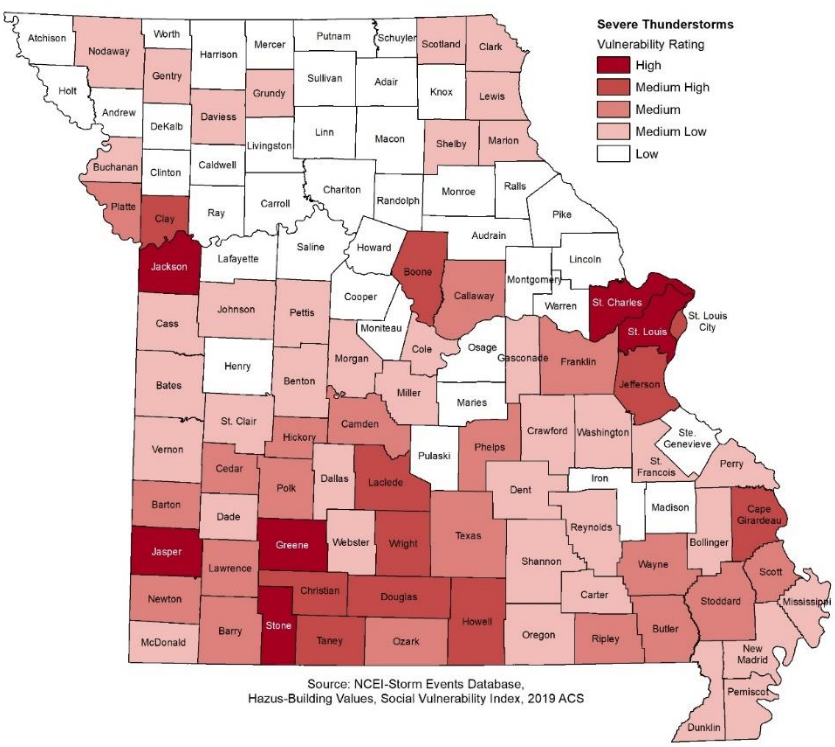
mobile home data from the U.S. Census (2019), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

From the statistical data collected, six factors were considered in determining overall vulnerability to lightning as follows: housing density, building exposure, percentage of mobile homes, social vulnerability, likelihood of occurrence, and average annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. Once the ranges were determined and applied to all factors considered in the analysis for wind, hail, and lightning, they were rated individually and factored together to determine an overall vulnerability rating for thunderstorms. These rating values correspond to the following descriptive terms:

1) Low
2) Medium-Low
3) Medium
4) Medium-High
5) High

All county-level statistical data tables, including ranges for vulnerability factor ratings, are presented in Appendix A. **Figure 3.110** present the vulnerability summary for severe thunderstorms.

Figure 3.110. Vulnerability Summary for Severe Thunderstorm



State Estimates of Potential Losses

To determine potential financial loss estimates to severe thunderstorms in Missouri, the available historical loss data was annualized. In the case of frequently occurring weather-related hazards such as severe thunderstorms, annualized historical loss data is considered to be the best resource for determining future potential losses. As discussed above in the vulnerability overview for this hazard, the planning team obtained historical loss data from the National Centers for Environmental Information for wind, hail, and lightning for the period from 1996 to December 2021.

Based on this data, the following figures provide the potential annualized loss estimates for high wind, hail, and lightning based on historical damages. The figures at the conclusion of this section provide the combined total annualized losses to provide a total potential loss estimate for the severe thunderstorm hazard. There are no distinct patterns of loss that can be inferred from the maps other than higher losses in areas with greater exposure. Thus, this analysis demonstrates the random distribution of this hazard and its impacts around the State of Missouri.

Figure 3.111. Annualized High Wind Damages (40 MPH or Greater)

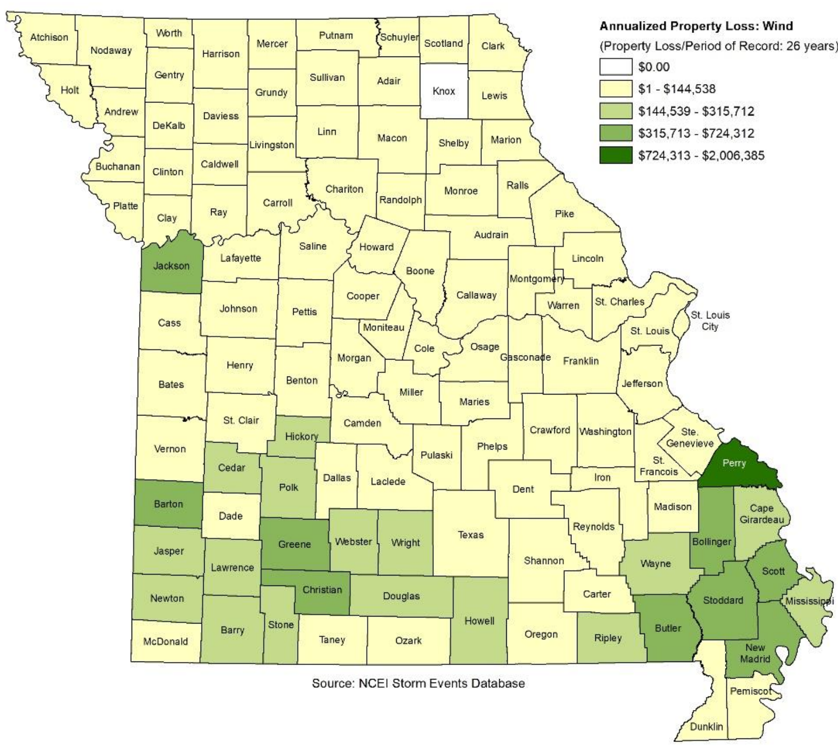


Figure 3.112. Annualized Hail Damages

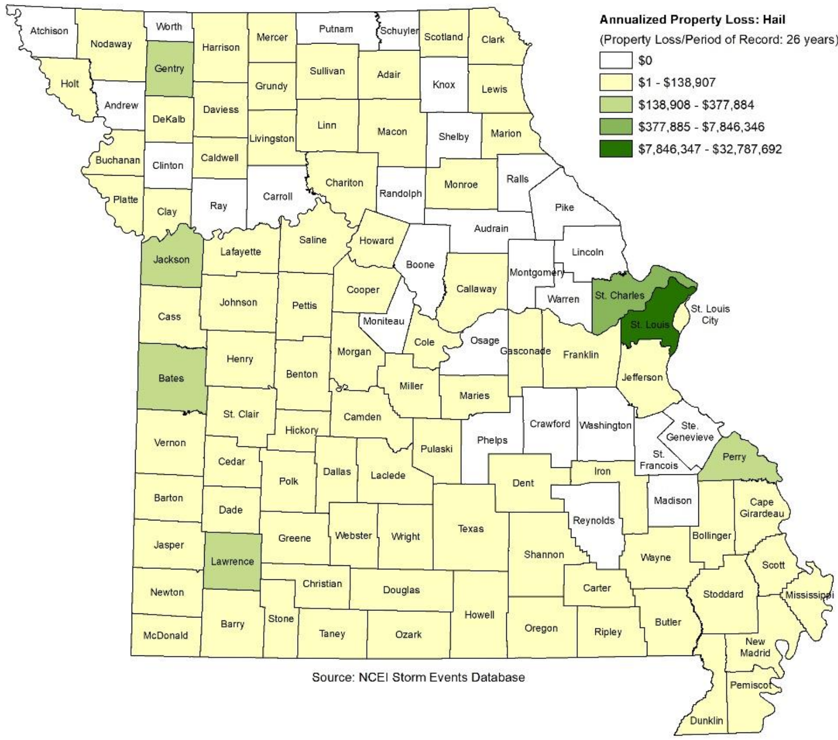


Figure 3.113. Annualized Lightning Damages

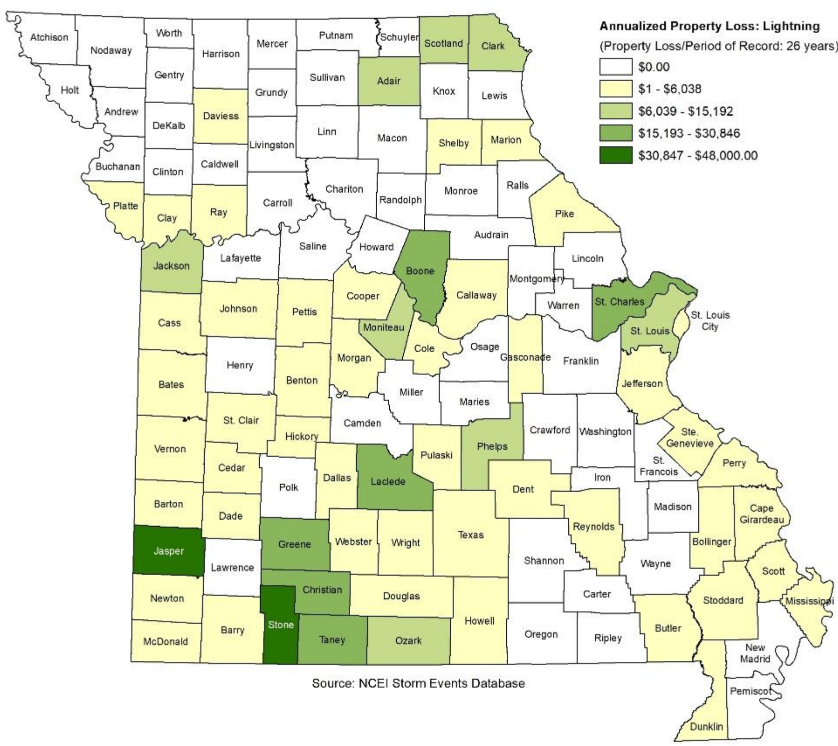


Figure 3.114. Annualized Wind Property Loss Ratio

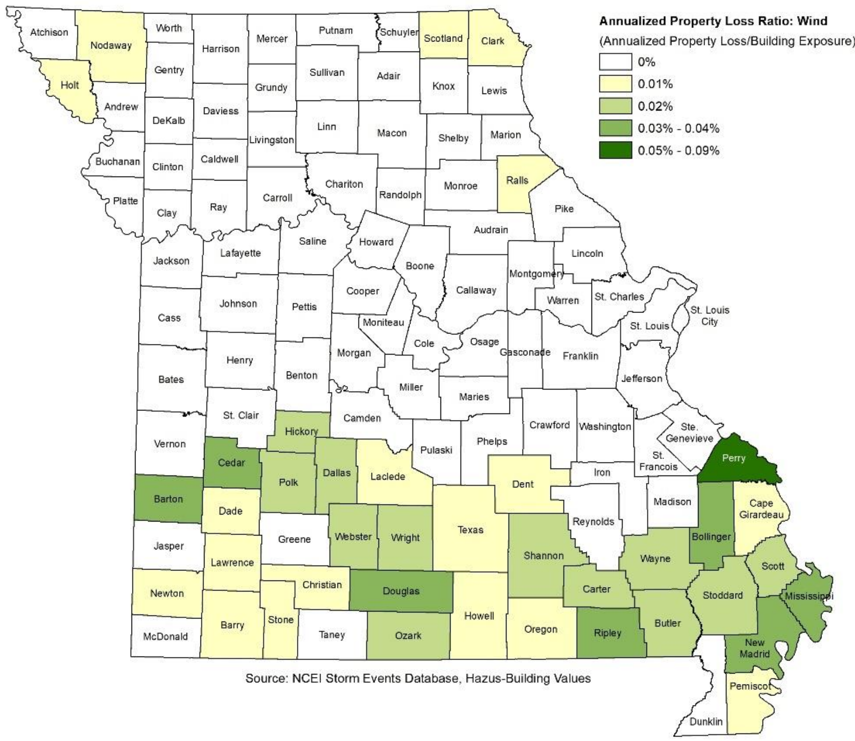


Figure 3.115. Annualized Hail Property Loss Ratio

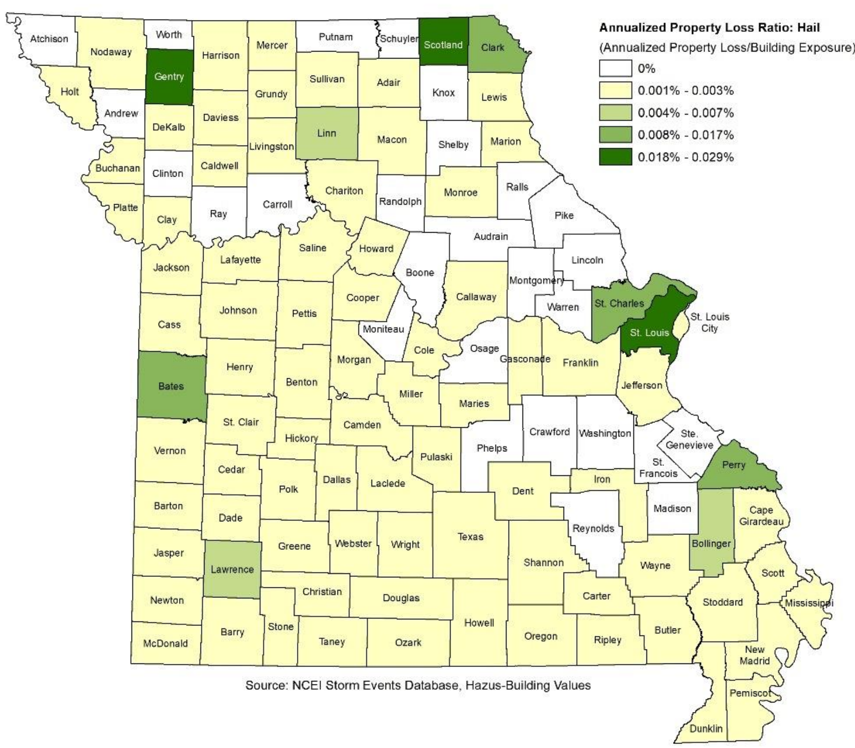
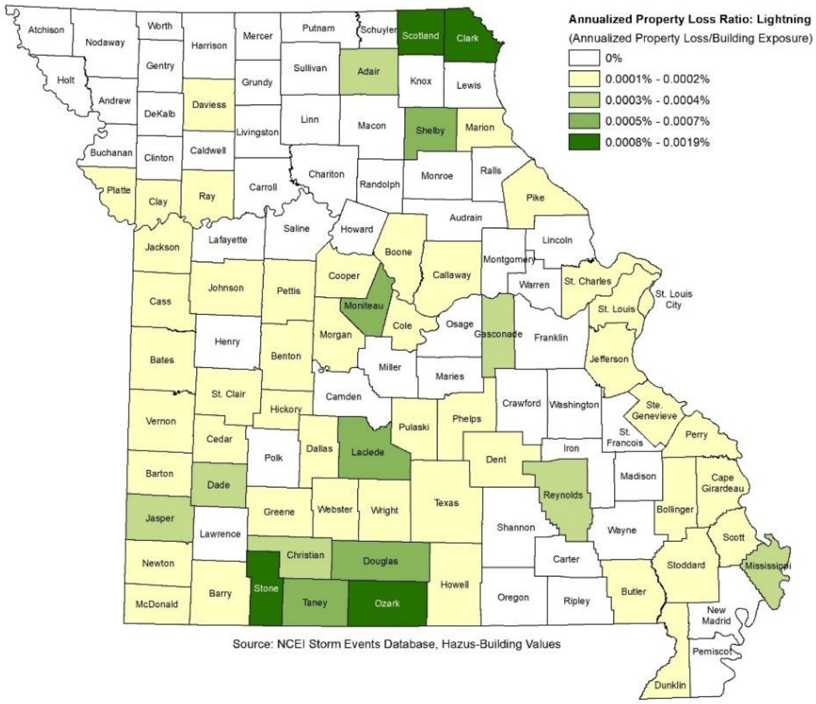


Figure 3.116. Annualized Lightning Property Loss Ratio



Hazard Impact on Future Growth and Development

The five counties that rated "High" in overall vulnerability to Severe Thunderstorms include Greene, Jackson, Jasper, St. Charles, St. Louis, and Stone Counties. All are experiencing housing gains, with the exception of St. Louis and Stone Counties. With growing population and increased development, there is potential for increased losses as a result of the increase in exposure. But this will be dependent on where the severe thunderstorms occur which is a variable that cannot be predicted due to the random nature of this hazard.

Risk Summary

Severe thunderstorms losses are usually attributed to associated hazards of hail, downburst winds, lightning and heavy rains. Losses to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside the State capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are accounted for in the riverine flooding profile.

Problem Statement:

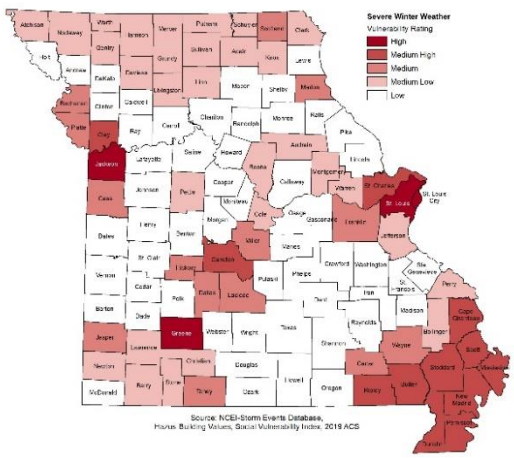
Using Vulnerability to Severe Thunderstorm as a key indicator, the most vulnerable areas are Jackson, Jasper, Greene, St. Charles, St. Louis and Stone Counties. Mitigation resources allocated to Severe Thunderstorms to these counties would be the most beneficial.

2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.9. Severe Winter Weather

Description

Severe winter weather, including snowstorms, ice storms, and extreme cold, can affect any area of Missouri. These events can interact to cause many hazards. Severe winter weather, such as snow, ice storms, and extreme cold can cause injuries, deaths, and property damage in a variety of ways.

Vulnerability – Severe Winter Weather	Extent/Range of Intensity
	Weather data indicates that the Missouri counties north of the Missouri River receive an average annual snowfall of 18 to 22 inches. Counties south of the Missouri River receive an annual average of 8 to 12 inches. The events that involve borderline conditions of freezing rain and ice are highly unpredictable. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. The durations of the more serious events combined with other factors, such as high winds, are also highly unpredictable.

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

People living areas south of the Missouri River have a lower probability of experiencing severe winter weather, however, households in this area may have homes with inadequate insulation, fail to maintain an adequate supply of home heating fuels, and be generally under prepared. Of winter deaths related to exposure to cold, 50 percent were over 60 years old. Counties with the most vulnerable populations are St. Louis City and Jackson, Greene and St. Louis Counties. Using Annualized Winter Weather Damages and Loss Ratios as key indicators, the most vulnerable counties are Dallas, Camden, Greene, Jackson, and St. Louis, along with the City of St. Louis.

Changing Future Conditions Considerations

A shorter overall winter season and fewer days of extreme cold may have both positive and negative indirect impacts. As both temperature and precipitation increase during the winter months, freezing rain will be more likely. Additional wintertime precipitation in any form will contribute to saturation and increase the risk and/or severity of spring flooding. A greater proportion of wintertime precipitation may fall as rain rather than snow.

Risk Summary/Problem Statement

As previously noted, snowstorms, ice storms, and extreme cold can interact to cause many hazards. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. Wind speed may be the difference between a minor snow and a blizzard. These events cannot be prevented. Preparedness for these events may be the greatest single factor to reduce loss of life, injury, and property damage. NOAA weather broadcasts via radio and television provide important information for people to prepare and thus reduce risks to their lives and property.

Description/Location

Severe winter weather, including snowstorms, ice storms, and extreme cold, can affect any area of Missouri. The greatest threat is likely to occur in the area north of the Missouri River, as with the devastating Kansas City area ice storm on January 31, 2002, which stretched into central Missouri and led to a presidential disaster declaration (DR-1403).

Severe winter weather, such as snow, ice storms, and extreme cold can cause injuries, deaths, and property damage in a variety of ways. Winter storms are considered deceptive killers. This is because most deaths are indirectly related to the storm. Causes of death range from traffic accidents due to adverse driving conditions such as icy roads, to heart attacks caused by overexertion while shoveling snow and from other related activities. Hypothermia or frostbite may be considered the most direct cause of death and injury that can be attributed to winter storms or severe cold.

Economic costs are also difficult to measure. Heavy accumulations of ice can bring down trees, electric power lines and poles, telephone lines, and communications towers (see **Figure 3.117**). Power outages create an increased risk of fire, as home occupants use alternative fuel sources (wood, kerosene, etc. for heat and fuel-burning lanterns or candles for emergency lighting). These storms can also affect utility and city operations due to debris removal and landfill hauling. In the 2002 ice storm, one home burned when ice-laden tree limbs fell and tore the electrical junction box from the outside of the home. Electrical sparks ignited a blaze that destroyed the home.

Figure 3.117. Power Poles Damaged by Severe Winter Weather, January 2009

Poplar Bluff, MO
(photo courtesy of SEMA)

Dexter, MO
(photo credit Southeast Missourian)

Crops and trees can be damaged, and livestock can be killed or injured due to deep snow, ice, or severe cold. Buildings and automobiles may be damaged from falling tree limbs, power lines, and poles. Local governments, home and business owners, and power companies are often faced with spending millions

of dollars to restore services, remove debris, and haul debris. Federal Public Assistance for local governments and Individual Assistance for citizens and businesses can help to cover much of the expense.

Extent /Range of Intensity

Weather data indicates that the Missouri counties north of the Missouri River receive an average annual snowfall of 18 to 22 inches. Counties south of the Missouri River receive an annual average of 8 to 12 inches. The events that involve borderline conditions of freezing rain and ice are highly unpredictable. The durations of the more serious events combined with other factors, such as high winds, are also highly unpredictable.

For severe weather conditions, the National Weather Service issues some or all of the following products as conditions warrant across the State of Missouri. NWS local offices in Missouri may collaborate with local partners to determine when an alert should be issued for a local area.

- **Winter Weather Advisory** — Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life threatening. Often the greatest hazard is to motorists.
- **Winter Storm Watch** — Severe winter conditions, such as heavy snow and/or ice are possible within the next day or two.
- **Winter Storm Warning** — Severe winter conditions have begun or are about to begin.
- **Blizzard Warning** — Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts, and life-threatening wind chill.
- **Ice Storm Warning --** Dangerous accumulations of ice are expected with generally over one quarter inch of ice on exposed surfaces. Travel is impacted and widespread downed trees and power lines often result.
- **Wind Chill Advisory --** Combination of low temperatures and strong winds will result in wind chill readings of -20 degrees F or lower.
- **Wind Chill Warning --** Wind chill temperatures of -35 degrees F or lower are expected. This is a life-threatening situation.

Additional information on Wind Chill is provided in **Section 3.3.7** Extreme Temperatures.

Previous Occurrences

Historical information on severe winter weather events was obtained from the NCEI Storm Database. **Table 3.61** through **Table 3.65** present annual events for ice storms, heavy snow, blizzards, winter storms, and winter weather, respectively. Significant events, including presidential disaster declarations, are further highlighted following each table.

Additional information on previous occurrences was obtained from the Missouri Department of Transportation (MODOT) and the USDA Risk Management Agency. MODOT incurs statewide annual costs for snow and ice removal. In an average winter, MoDOT plows approximately 6 million miles of snow and ice. According to the MoDOT Tracker, which measures the MoDOT performance, the cost for winter operations from 2020 to 2021 was $57.8 million. This amount can vary drastically from year to year due to weather conditions. Over the last five years, the annual cost of winter operations ranged

from $25 million to $66 million. According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of cold wet winter, cold winter, freeze, and frost conditions for the ten-year period of 2012 through 2021 totaled $48,075,301.

Table 3.61. Annual Ice Storm Events in Missouri, 1996-2021

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	46	0	0	4,235,000	0
1997	32	0	0	0	0
1998	40	0	0	0	0
1999	32	0	0	150,000	0
2000	37	0	0	10,000	0
2001	44	0	0	25,000	0
2002	32	0	0	$32,437,000	$0
2003	0	0	0	$0	$0
2004	24	0	0	$0	$0
2005	21	0	0	$20,000	$0
2006	30	0	0	$10,000	$0
2007	152	0	0	$373,213,000	$0
2008	94	0	0	$0	$0
2009	12	0	0	$50,190,000	$0
2010	1	0	0	$0	$0
2013	15	0	0	$750,000	$0
2014	0	0	0	$0	$0
2015	0	0	0	$0	$0
2016	0	0	0	$0	$0
2017	48	0	0	$100,000	$0
2018	9	0	0	$0	$0
2019	49	0	0	$25,000	$0
2020	5	0	0	$0	$0
2021	0	0	0	$0	$0
Grand Total	**723**	**0**	**0**	**$461,165,000**	**$0**

Significant ice storm events include the following:

January 31, 2002 (DR-1403): A massive severe winter storm system dumped snow and ice from Oklahoma to Kansas and into central and northern Missouri. In Missouri alone, more than 600,000 residents were without power, as ice-encased power lines snapped in fierce winds or were pulled down by falling trees and limbs. Loss of electricity included more than 460,000 people in the Kansas City metro area alone (Jackson, Cass, Clay, and Platte counties). Additionally, residents in a line from Kansas City to the Iowa-Illinois border were without power as rural electric cooperative lines broke as well. Outages ranged from several days to nearly two weeks. Damage to property, power restoration, and the cost of debris removal for local governments was so high that Missouri received a presidential disaster

declaration (DR-1403) on February 6, 2002, which ultimately included 43 counties; 26 were designated for both Individual and Public Assistance, and 17 were eligible for Individual Assistance only. The total eligible Public Assistance costs for this disaster ($61.9 million dollars as of August 2002) ranks the 2002 ice storm as Missouri's second most costly disaster to date.

January 2007: One of the greatest disasters to ever impact southwest Missouri, including the Springfield metro area, occurred in the form of an ice storm. Several counties, mainly along and north of the interstate 44 corridor, experienced ice accumulations up to two and a half inches. Power outages and catastrophic tree damage were the main impacts resulting from this historic event. Power outages occurred for over three weeks in many areas. Several indirect fatalities due to the extreme elements were documented. Carbon monoxide poisoning occurred within a few homes as gas generators were being used in garages, which allowed for dangerous levels of carbon monoxide to seep into houses.

December 6, 2007 (DR-1736): A major ice storm hit parts of central, northeast, and east central Missouri. Up to a half inch of ice accumulated along with up to one inch of sleet. Trees and power lines were down throughout the area. Many businesses had to close due to loss of electricity. Schools across the area were closed for several days. Over 32,000 power outages were reported in Boone, Callaway, Cole, Lincoln, Moniteau, and Pike Counties. Shelters were opened in Cole, Pike and Warren Counties. From 50 to 60 people stayed at the shelters in Cole County at various times with over 100 coming in daily for hot meals. There were two fatalities reported in automobile accidents across mid-Missouri.

Another round of freezing rain was observed from December 9th through December 11, 2007. A slow-moving storm system brought a long duration of freezing rain to a large portion of the nation's mid-section. Canadian high pressure kept cold air at the surface with readings in the upper 20s to lower 30s. Very warm and moist air aloft was transported north ahead of the storm system. The result of these two ingredients led to several rounds of freezing rain. Ice rapidly accumulated on many surfaces, especially trees and power lines. Ice accumulation was particularly devastating along and north of the Missouri River. Ice accumulations of 3/4 of an inch were common, with isolated accumulations around an inch, along and north of a Bean Lake to Trenton, to Unionville line. Along and south of the Interstate 70 corridor, accumulations were less than a half inch. Numerous tree branches and power lines were downed, especially along and north of a St. Joseph to Unionville. Around 165,000 residents went without power, some for almost two weeks. Twenty Missouri electric cooperatives in the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $10.8 million. There were also numerous traffic accidents due to the icy roads.

February 10-14, 2008 (DR-1748): A wintry mix of precipitation affected a large area of the southern half of Missouri for a map of the counties that received disaster declarations). A significant ice even occurred. Over 15,000 power outages were reported and some continued for almost two weeks. Fourteen Missouri Electric Cooperatives that belong to the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $5.1 million. Shelters and feeding stations were set up in numerous counties. There were two storm-related traffic fatalities and 54 storm-related traffic injuries.

January 2009: A significant winter storm brought a combination freezing drizzle, freezing rain, sleet, and snow to the Missouri Ozarks. This ice storm downed tree limbs and power lines causing numerous power outages. As many as 20,000 residences lost power along the Arkansas border from Branson to

Alton. As much as 6 inches of sleet fell across far south-central Missouri. The weight of freezing rain and sleet across far southern Missouri caused the roofs of several buildings and a boat dock to collapse. The sleet transitioned to snow toward the end of the event with 2 to 4 inches of snow common on top of the freezing rain and sleet.

January 2017: A significant ice storm impacted the Missouri Ozarks with sporadic power outages and some tree damage. Up to a half an inch of ice accumulated on elevated objects and tree limbs across the northern portion of the county during the ice storm. There were up to 4,000 people without power across north Springfield due fallen tree limbs on power lines.

Table 3.62. Annual Heavy Snow Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	6	0	0	$1,500,000	$0
1997	65	0	2	$10,470,000	$0
1998	0	0	0	$0	$0
1999	24	0	0	$0	$0
2000	107	0	0	$450,000	$0
2001	31	0	0	$0	$0
2002	48	0	0	$0	$0
2003	45	0	0	$6,020	$0
2004	19	0	0	$0	$0
2005	11	0	0	$0	$0
2006	36	0	0	$6,000	$0
2007	41	0	0	$0	$0
2008	43	0	0	$0	$0
2009	14	0	0	$0	$0
2010	23	0	0	$0	$0
2011	20	0	0	$0	$0
2013	54	0	0	$0	$0
2014	38	0	0	$0	$0
2015	63	0	0	$0	$0
2016	0	0	0	$0	$0
2017	0	0	0	$0	$0
2018	18	0	0	$0	$0
2019	36	0	0	$0	$0
2020	16	0	0	$0	$0
2021	19	0	0	$0	$0
Grand Total	**778**	**0**	**2**	**$12,432,020**	**$0**

Significant heavy snow events include the following:

December 2000: A major winter storm dropped as much as 14 inches of snow across the Missouri Ozarks. The hardest hit areas were along I-44 from Joplin to Lebanon. In these areas, over a foot of snow was reported. Lesser amounts were found near the Arkansas border where some sleet and freezing rain mixed in with the snow. Due to the weight of the heavy snowfall, some roofs and carports were damaged along with some minor power outages. In addition, a turkey farm was damaged in Ozark County, an appliance store outdoor canopy collapsed in Nevada, and a sports complex dome collapsed in Joplin due to the heavy snowfall. Although numerous accidents and road closures were reported, no serious injuries occurred.

November 30–December 1, 2006 (DR-1673): A severe winter storm dropped freezing rain, sleet, ice, and snow over Missouri for a map of the counties that received disaster declarations). According to Pat Guinan, University of Missouri climatologist, the storm was unprecedented for the time of year it hit. Some areas of the State experienced up to 14 inches of snow. The freezing rain and sleet caused major power outages, blocked roads, and caused structural damage to buildings across the State. Eleven deaths were attributed to the event.

Table 3.63. Annual Blizzard Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1998	0	0	0	$0	$0
1999	0	0	0	$0	$0
2000	0	0	0	$0	$0
2001	0	0	0	$0	$0
2002	0	0	0	$0	$0
2003	0	0	0	$0	$0
2004	0	0	0	$0	$0
2005	0	0	0	$0	$0
2006	0	0	0	$0	$0
2007	0	0	0	$0	$0
2008	0	0	0	$0	$0
2009	32	0	0	$0	$0
2010	0	0	0	$0	$0
2011	76	1	0	$140,000	$0
2012	10	0	0	$0	$0
2013	0	0	0	$0	$0
2014	0	0	0	$0	$0
2015	0	0	0	$0	$0
2016	0	0	0	$0	$0
2017	0	0	0	$0	$0
2018	49	0	0	$0	$0
2019	0	0	0	$0	$0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2020	0	0	0	$0	$0
2021	0	0	0	$0	$0
Totals	**167**	**1**	**0**	**$140,000**	**$0**

Significant blizzard events include the following:

December 2009: A powerful storm system brought heavy snow, ice and even blizzard conditions, to a large portion of the central plains, on December 7-9, 2009. The greatest impact occurred across north central and northeast Kansas, southeast Nebraska, northwest and north central Missouri, and both southern and eastern Iowa, where strong winds gusting up to 45 mph produced blizzard conditions. The heaviest snowfall also occurred in these areas, where accumulations of 8 to 12 inches were common. The greatest snow total was 14 inches, observed in Rockport, Missouri.

January 31, 2011 to February 5, 2011 (DR-1961): The first true blizzard in many years hit from Central to Northeast Missouri. Up to 20 inches of snow fell along with winds gusting over 40 mph. For many counties it was a record snowfall event. The National Guard was called out to help clear County roads and assist with emergency transportation. The region was brought to a standstill for several days. A Federal disaster declaration was obtained for many counties in order to assist with the cost of snow removal. Light freezing rain and sleet started to fall on Monday 1/31 with an inch of sleet accumulating by the early morning hours of Tuesday (2/1). By midday Tuesday (2/1) the precipitation had changed to snow and the wind started to increase. I-70 was shut down from Warren County to just east of Kansas City about 8 pm that evening. The snow tapered off to flurries by Wednesday (2/2) morning. The strong wind continued through the day producing very cold wind chill values.

Table 3.64. Annual Winter Storm Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	64	0	0	$10,000	$0
1997	167	0	0	$20	$0
1998	132	0	0	$0	$0
1999	108	0	0	$3,030,000	$0
2000	123	0	0	$0	$0
2001	99	0	0	$260,000	$0
2002	191	0	0	$600,000	$0
2003	251	0	0	$0	$0
2004	146	0	0	$2,000	$0
2005	51	2	0	$0	$0
2006	100	0	67	$321,845,700	$0
2007	70	0	0	$8,000	$0
2008	83	0	0	$9,152,000	$0
2009	94	0	0	$120,450,000	$0
2010	104	0	0	$0	$0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2011	134	0	0	$0	$0
2012	20	0	0	$0	$0
2013	252	0	0	$0	$0
2014	162	0	0	$1,010,000	$0
2015	117	0	0	$204,000	$0
2016	2	0	0	$30,000	$0
2017	0	0	0	$0	$0
2018	6	0	0	$0	$0
2019	83	0	0	$0	$0
2020	48	0	0	$0	$0
2021	107	0	0	$520,000	$0
Grand Total	**2,715**	**2**	**67**	**$457,121,720**	**$0**

Significant winter storm events include the following:

January 1999: At one point late on the 1st and early on the 2nd, the Barton County Electrical Cooperative lost power to 4,500 members out of a 5,800-member system. Numerous wires, power lines, and trees were downed due to a heavy ice accumulation. In south central Missouri, the Howell-Oregon Electric Cooperative lost power to 16,000 of its 21,000 members due to downed power lines and trees from a heavy ice accumulation. Some customers were without power for 6 days. Ice accumulated to 2 inches in some locations in south central Missouri. In central Missouri on January 2nd, the Empire Electric Cooperative said that power had been interrupted to 35,000 of its customers due to downed power lines from a heavy ice accumulation. On January 1st, one person was killed, and one was injured when their car struck a bridge railing and overturned into a creek in Pulaski County. A band of snow and sleet (in addition to the ice) fell from southwest to central Missouri. Three-to-six-inch amounts occurred in southwest Missouri in the Springfield, Galena, Ozark, and Buffalo areas. Heavier amounts of 5 to 10 inches occurred in central Missouri near the Lake of the Ozarks. The heaviest 8 to 10 inches of snow occurred in Morgan and northern Miller Counties. In some rural areas, schools remained closed for nearly two weeks after the Christmas/New Year holiday period.

November 2006: A major winter storm hit central, northeast, east central and parts of southeast Missouri from November 30 through December 1. Over a foot of snow fell across parts of central Missouri while a major ice storm hit parts of east central and southeast Missouri, including the St. Louis area. Ice accumulations of 1 inch or more downed trees and power lines resulting in at least 300,000 electric customers losing service for up to a week. Downed limbs and trees damaged homes and automobiles across the area as well. Many rural schools were closed for several days due to slick roads and power outages. The National Guard was called out to several counties to assist with debris removal and other emergency services. Damages across the region were expected to be in excess of $100 million.

January 12–14, 2007 (DR-1676): A series of severe winter storms swept across Missouri causing heavy damage throughout the State. An area from Joplin to St. Louis along the I-44 corridor was the heaviest hit for a map of the counties that received disaster declarations). The storm system caused power

outages for over 330,000 households/businesses statewide, caused 15 weather-related deaths, and sent over 4,300 citizens to more than 119 shelters. Preliminary eligible costs for Public Assistance were estimated at $109.3 million. Of this amount, approximately $51 million in damages was estimated by the 15 Missouri Electric Cooperatives that sustained damage to their electrical lines, substations and equipment.

January 26-29, 2009 (DR-3303 and DR-1822): A cold front mixed with Gulf moisture created ice and freezing rain. High winds on February 11th caused additional damage in southern Missouri for a map of the counties that received disaster declarations). There were eight fatalities associated with this storm (six in traffic accidents and two with carbon monoxide poisoning). Up to 8000 customers were without power and some were out over three weeks. Seven Missouri Electric Cooperatives that are part of the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $175 million.

January 2014: A very strong winter storm dropped 6 - 12 inches of snow across East Central Missouri. Strong northerly winds produced snow drifts of 2 to 5 feet. All schools and most businesses were closed on the 5th and 6th, with many schools remaining closed for several days due to very cold temperatures and wind chills. The City of St. Louis estimated at least $1 million was spent on snow removal.

February 2016: A combination of heavy wet snow and strong winds during the morning hours produced major impacts in parts of southeast Missouri. From 4 to 7 inches of heavy wet snow fell in the Perryville area, including most of Perry County. The highest impacts were in Perry County, where widespread power outages knocked out power to 90 percent of Perryville. Sustained north winds ranged from 20 to 30 mph, with gusts to around 45 mph. Further south, from 1 to 3 inches of heavy wet snow fell as far south as a line from Cape Girardeau to Greenville in Wayne County. The snow fell heavily for a few hours, reducing visibility as low as one-quarter mile. Roads were very slick and hazardous. Dozens of cars slid off roads.

January 2021: A storm system lifted northward through Arkansas and into Missouri from New Year's Eve into New Year's Day. Freezing rain spread into southeast Kansas and southern and central Missouri. The freezing rain continued before transitioning over to minor accumulations of snow. Ice accumulations resulted in tree damage and scattered power outages.

Table 3.65. Annual Winter Weather Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	11	0	0	$0	$0
1997	0	0	0	$0	$0
1998	24	0	0	$0	$0
1999	0	0	0	$0	$0
2000	21	0	0	$0	$0
2001	4	0	0	$0	$0
2002	0	0	0	$0	$0
2003	14	0	0	$0	$0
2004	0	0	0	$0	$0
2005	14	0	0	$0	$0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2006	51	0	0	$5,000	$0
2007	86	0	0	$0	$0
2008	76	0	0	$0	$0
2009	15	0	0	$0	$0
2010	78	0	0	$0	$0
2011	127	0	0	$4,000	$0
2012	95	0	0	$0	$0
2013	60	0	0	$0	$0
2014	41	0	0	$0	$0
2015	47	0	0	$10,000	$0
2016	42	0	0	$1,000,000	$0
2017	27	0	0	$0	$0
2018	83	0	0	$250,000	$0
2019	65	0	0	$1,610,000	$0
2020	48	0	0	$10,000	$0
2021	145	0	0	$225,000	$0
Totals	**1,175**	**0**	**0**	**$3,114,000**	**$0**

Significant winter weather events include the following:

February 15–16, 1993: Central and southern Missouri was covered with up to 21 inches of snow. The airport at Cape Girardeau received 6 inches of snow in one hour and 20 minutes.

January 14–20, 1994: Northeast, central, and east-central Missouri experienced overnight low temperatures from below zero to –20°F. Hundreds of homes and businesses had frozen and busted water pipes. Wind chills, which ranged from -30 to -50°F, kept schools closed and accounted for 15 people being admitted to local hospitals for hypothermia and frostbite.

January 16–17, 1994: A layer of ice up to 2 inches thick formed over sections of southeast Missouri, followed by 6 to 10 inches of snow. Some areas were without power for more than 24 hours. Roofs collapsed due to the heavy weight of snow and ice.

December 6, 1994: Ice accumulations of 0.5 to 1 inch were reported across northwest, north central, and northeast Missouri. Over 75 percent of the residents in this region were without power. Phone and cable television were also out. A few rural areas were without power for at least seven days. The City of St. Joseph was declared a disaster area by Governor Mel Carnahan because of damage totaling nearly $4 million.

January 18–19, 1995: Central Missouri received heavy snows, dumping 19.7 inches over Columbia alone and setting a new 24-hour snowfall record. Parts of I-70, I-44, and other major highways were closed due to drifting snow. Snow fell at such a fast rate that snowplows and graders became stuck. Almost 5,000 birds were killed when several large chicken and turkey barns collapsed. Thousands of people were without power and telephone service. The Jefferson City and Columbia airports were closed for a

time. The University of Missouri at Columbia canceled classes for the first time in nearly 17 years. State offices in Jefferson City were also closed.

October 22–23, 1996: An early snowfall hit the Kansas City area, dumping as much as 8.5 inches of heavy wet snow. Approximately 130,000 residences were without power, and an estimated $1.5 million in property damage was reported.

January 10–13, 1997: Northwest and west-central Missouri experienced overnight low temperatures below zero. No record low temperatures were recorded, but winds gusting up to 30 miles per hour produced afternoon wind chills as low as -30 to -50°F.

April 10–11, 1997: A spring snowstorm dumped up to 24 inches in extreme north Missouri. Schuyler County alone reported $2 million in damage, mostly due to the heavy snow causing roofs on farm buildings to collapse.

December 2016: Freezing drizzle caused major travel impacts and numerous accidents around the Missouri Ozarks. There were a few fatalities associated with car accidents which were indirectly caused by the icy road conditions. Two Sunrise Beach firefighters were injured when their fire truck was involved in an accident due to slick road conditions. The fire truck was totaled. The Osage Beach fire department assist in more than a dozen vehicle crashes due to slick road conditions. An Osage Beach fire truck was damaged in an accident.

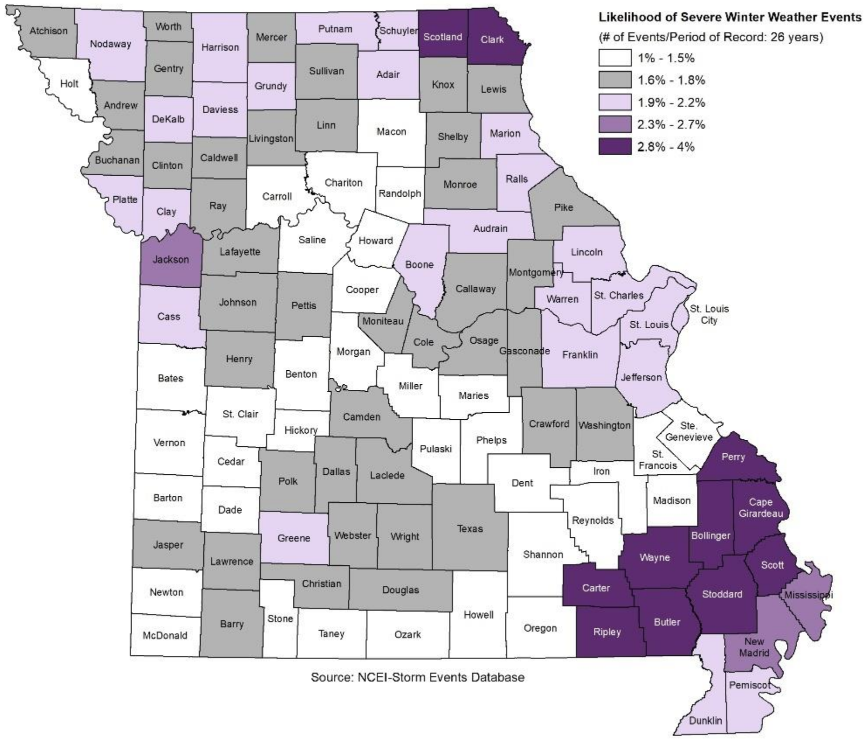
January 2016: Widespread freezing drizzle caused significant travel problems around the Springfield metro area during the afternoon and evening commute. While accidents also occurred elsewhere in southwest Missouri, there was a much greater concentration of accidents in and around Springfield/Greene County. A thin glaze of ice from freezing drizzle caused very high impacts and over 50 motor vehicle accidents and slide offs across Greene County and the Springfield metro area during the afternoon and evening commute. Over a dozen accidents involving school buses were reported as well. Some of the accidents resulted in some damage to guard rails, traffic lights, traffic signs, and fences along the roads. Roadways were extremely hazardous and impassable in some places. There were some minor injuries reported but no serious injuries or fatalities.

February 2019: After a couple hours of moderate to heavy snow, around 3 to 4 inches accumulated on local roads, including I-70 just east of Kansas City. The slick roads and highly reduced visibility caused a massive pile up at the Oak Grove exit on WB I-70. Several injuries occurred in this accident and one fatality occurred in the carnage that ensued. The pile up received high profile coverage on national media

Probability of Future Hazard Events

Severe Winter Weather is a common occurrence in Missouri. The total number of winter weather events recorded through the NCEI, including Blizzard, Heavy Storm, Ice Storm, Winter Storm and Winter Weather, was 5,556 over a 26-year period from 1996 through 2021. This results in approximately 213 events per year or a 100% probability.

Figure 3.118. Average Annual Occurrence of Severe Winter Weather Events



Changing Future Conditions Considerations

A shorter overall winter season and fewer days of extreme cold may have both positive and negative indirect impacts. Warmer winter temperatures may result in changing distributions of native plant and animal species and/or an increase in pests and non-native species. Warmer winter temperatures will result in a reduction of lake ice cover. Reduced lake ice cover impacts aquatic ecosystems by raising water temperatures. Water temperature is linked to dissolved oxygen levels and many other environmental parameters that affect fish, plant, and other animal populations. A lack of ice cover also leaves lakes exposed to wind and evaporation during a time of year when they are normally protected. As both temperature and precipitation increase during the winter months, freezing rain will be more likely. Additional wintertime precipitation in any form will contribute to saturation and increase the risk and/or severity of spring flooding. A greater proportion of wintertime precipitation may fall as rain rather than snow.

State Vulnerability Overview

For areas north of the Missouri River, the probability of a snowstorm, ice storm, or extreme cold should be considered high due to historically higher average snowfall and lower average temperatures. However, the SRMT has the rated the severity as moderate due local knowledge of the overall level of preparedness in this area. For example, homes and businesses may be better insulated due to the higher probability of severe cold relative to other areas. Also, people living in this area may be more likely to use snow tires or purchase four-wheel-drive vehicles. People living in this area may be more likely to maintain adequate supplies of home heating fuels and consider other preparedness measures. Local and state governments

may have access to more snow clearing equipment and maintain adequate supplies of materials needed for snow or ice removal. School districts and businesses may be more likely to develop and use snow routes or establish closing procedures.

Areas south of the Missouri River have a lower probability of a snowstorm, ice storm, or extreme cold due to their lower average snowfalls and temperatures. Events in these areas also have a moderate potential severity. This may be due to a lower level of preparedness. People living in this area may have homes with inadequate insulation or fail to maintain an adequate supply of home heating fuels. People may be less likely to equip their vehicles with snow tires or purchase four-wheel-drive vehicles. Local and state governments may not maintain sufficient amounts of equipment and materials. Schools and businesses may not have formal snow routes or closing procedures.

People are adversely affected by winter storms, ice storms, and extreme cold, some more than others. Observations by the National Oceanic and Atmospheric Administration (NOAA) indicate that of winter deaths related to exposure to cold, 50 percent were over 60 years old, over 75 percent were male, and about 20 percent occurred in the home. Of winter deaths related to ice and snow, about 70 percent occur in automobiles, and 25 percent are people caught in storms. As noted earlier, ice storms can result in significant economic costs to homeowners, business owners, and utility companies. The ice storm in December 1994 demonstrated the environmental damage that can occur. Thousands of trees and plants were cut down or damaged as a result of the ice storm. The problem of debris clearance caused environmental impacts due to the permitted burning of debris and reduced landfill space.

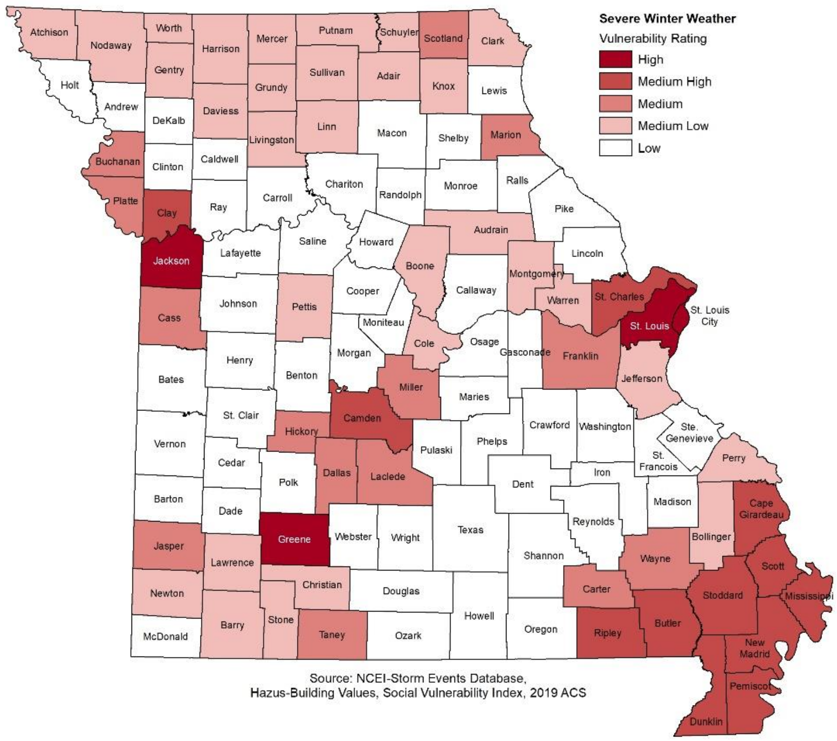
The method used to determine vulnerability to severe winter weather across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2021), HAZUS Building Exposure Value data, housing density data from the U.S. Census (2019), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

From the statistical data collected, five factors were considered in determining overall vulnerability to severe winter weather as follows: housing density, building exposure, social vulnerability, likelihood of occurrence, and average annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. Once the individual ratings were determined for the above factors, a combined vulnerability rating was computed for severe winter weather. These rating values correspond to the following descriptive terms:

1) Low
2) Medium-Low
3) Medium
4) Medium-High
5) High

All county-level statistical data tables, including ranges for vulnerability factor ratings, are presented in Appendix A. **Figure 3.119** present the vulnerability summary for severe winter weather.

Figure 3.119. Vulnerability Summary for Severe Winter Weather



Source: NCEI-Storm Events Database,
Hazus-Building Values, Social Vulnerability Index, 2019 ACS

State Estimates of Potential Losses

To determine potential financial loss estimates to severe winter weather in Missouri, the available historical property loss data was annualized. In the case of frequently occurring weather-related hazards such as severe winter weather, annualized historical loss data is considered to be the best resource for determining future potential losses. As discussed above in the vulnerability overview for this hazard, the planning team obtained historical loss data from the NCEI Storm Event Database for Blizzard, Heavy Storm Ice Storm, Winter Storm and Winter Weather for the period from 1996 to December 2021. The total property damage was $933,972,740 which results in approximately $35,922,028 in property loss per year.

Based on this data, the figures below provide the potential annualized loss estimates for total winter weather historical damages. There are no distinct patterns of loss that can be inferred from the maps other than higher losses in areas with greater exposure. Thus, this analysis demonstrates the random distribution of this hazard and its impacts around the State of Missouri.

Figure 3.120. Annualized Winter Weather Damages

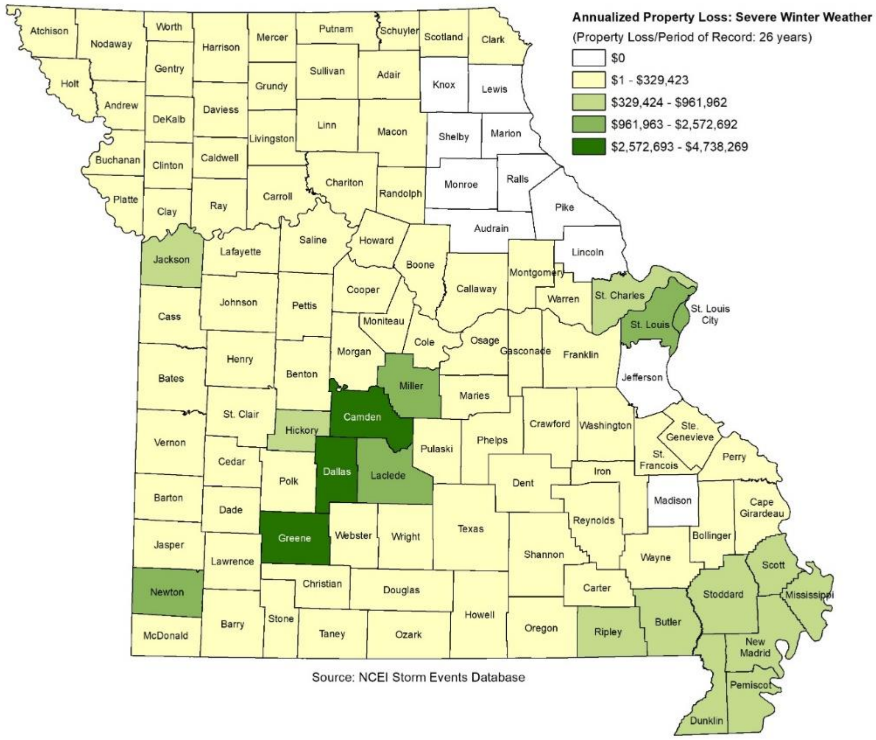
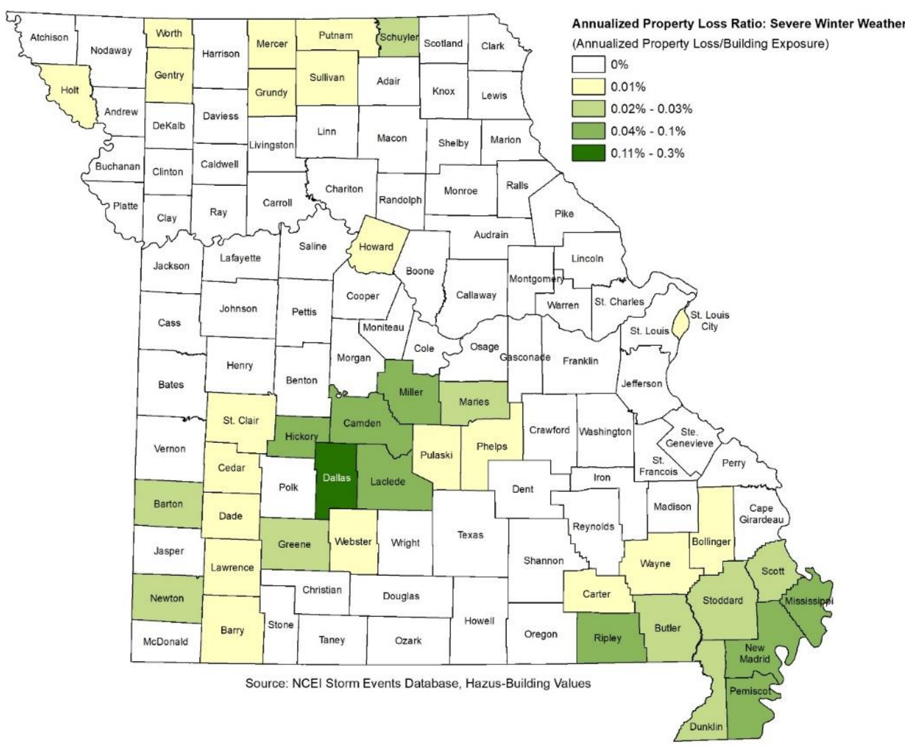


Figure 3.121. Annualized Winter Weather Property Loss Ratio



Hazard Impact on Future Growth and Development

In recent years, the weather pattern has caused more changes than development trend changes in Missouri. Future development could potentially increase vulnerability to this hazard by increasing demand on the utilities and increasing the exposure of infrastructure networks.

According to the overall vulnerability summary for winter storms, the following counties have high vulnerability ratings: Greene, Jackson, St. Louis, and St. Louis City. Both Greene and Jackson Counties have growing population rates.

Risk Summary

As previously noted, snowstorms, ice storms, and extreme cold can interact to cause many hazards. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. Wind speed may be the difference between a minor snow and a blizzard. These events cannot be prevented. Preparedness for these events may be the greatest single factor to reduce loss of life, injury, and property damage. NOAA weather broadcasts via radio and television provide important information for people to prepare and thus reduce risks to their lives and property.

Problem Statement:

Using Vulnerability for Severe Winter Weather as a key indicator, the counties with the most vulnerable populations are St. Louis City and Jackson, Greene and St. Louis Counties. Using Annualized Winter Weather Damages and Loss Ratios as key indicators, the most vulnerable counties are Dallas, Camden, Greene, Jackson, and St. Louis, along with the City of St. Louis. Mitigation efforts and dollars focused on these areas would likely prove most effective.

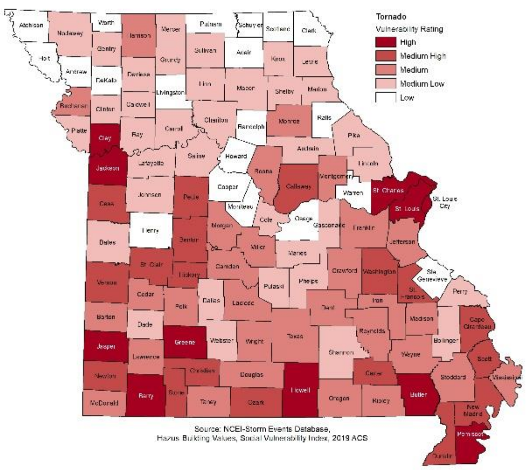
2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.10. Tornados

Description

Tornadoes are cyclical windstorms often associated with the Midwestern areas of the United States. Weather conditions conducive to tornadoes often produce a wide range of other dangerous storm activities, including severe thunderstorms, downbursts, straight-line winds, lightning, hail, and heavy rains.

Vulnerability – Tornados



Extent/Range of Intensity

Historically, Missouri has experienced numerous tornadoes of varied intensities. On average, a tornados touchdown lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. About 2,772 tornadoes occurred in Missouri from 1950 to December 31, 2021, with 402 deaths and over $5.3 billion in damage.

Probability	Severity	Location
100%	High	Statewide

State Vulnerability Overview

Many tornados are capable of great destruction. Tornadoes can topple buildings, roll mobile homes, uproot trees, hurl people and animals through the air for hundreds of yards, and fill the air with lethal, windblown debris. With growing population and increased development, there is potential for increased losses as a result of the increase in exposure. But this will be dependent on where the severe thunderstorms occur which is a variable that cannot be predicted due to the random nature of this hazard. Using Overall Vulnerability to Tornado as a key indicator, the most vulnerable counties are Barry, Butler, Clay, Greene, Howell, Jackson, Jasper, Pemiscot, St. Charles, and St. Louis, as well as, the City of St. Louis.

Changing Future Conditions Considerations

Scientists do not know how the frequency and severity of tornadoes will change. Changes in heat and moisture content in the atmosphere, brought on by a warming world, could be playing a role in making tornado outbreaks more common and severe in the U.S. The number of days with large outbreaks have been increasing since the 1950s and that densely concentrated tornado outbreaks are on the rise. Areas already subject to tornado activity are seeing more densely packed tornadoes.

Risk Summary/Problem Statement

The potential severity of effects from tornadoes will continue to be high. Missouri will continue to experience deaths, injuries, and property damage from tornadoes. However, technological advances will facilitate earlier warnings than previously available. This, combined with a vigorous public education program and improved construction techniques, provides the potential for significant reductions in the number of deaths and injuries, as well as reduced property damage.

Description/Location

Tornadoes are cyclical windstorms often associated with the Midwestern areas of the United States. Weather conditions conducive to tornadoes often produce a wide range of other dangerous storm activities, including severe thunderstorms, downbursts, straight-line winds, lightning, hail, and heavy rains. For the purpose of this analysis, tornadoes are considered in one category. Other severe weather activities associated with tornadoes are profiled separately in this document in **Section 3.1.8** Severe Thunderstorms. **Figure 3.122** illustrates damage from a tornado that struck Joplin, MO on May 22, 2011.

Figure 3.122. May 22, 2011, Joplin, Missouri EF5 Tornado Damage

Source: Mark Schiefelbein/Associated Press

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles per hour, and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside.

Although tornadoes have been documented in all 50 states, most of them occur in the central United States. The unique geography of the central United States allows for the development of thunderstorms that spawn tornadoes. The jet stream, which is a high-velocity stream of air, determines which area of the central United States will be prone to tornado development. The jet stream normally separates the cold air of the north from the warm air of the south. During the winter, the jet stream flows west to east from Texas to the Carolina coast. As the sun “moves” north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move northward in the spring and

its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

Tornadoes spawn from the largest thunderstorms. The associated cumulonimbus clouds can reach heights of up to 55,000 feet above ground level and are commonly formed when Gulf air is warmed by solar heating. The moist, warm air is overridden by the dry cool air provided by the jet stream. This cold air presses down on the warm air, preventing it from rising, but only temporarily. Soon, the warm air forces its way through the cool air and the cool air moves downward past the rising warm air. This air movement, along with the deflection of the earth's surface, can cause the air masses to start rotating. This rotational movement around the location of the breakthrough forms a vortex, or funnel. If the newly created funnel stays in the sky, it is referred to as a funnel cloud. However, if it touches the ground, the funnel officially becomes a tornado.

A typical tornado can be described as a funnel-shaped cloud that is "anchored" to a cloud, usually a cumulonimbus that is also in contact with the earth's surface. This contact on average lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length at 2.27 miles and the mean path area at 0.14 square mile.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Tornadoes are most likely to occur in the afternoon and evening but have been known to occur at all hours of the day and night.

Extent /Range of Intensity

Tornadoes are classified according to the EF- Scale (the original F – Scale was developed by Dr. Theodore Fujita, a renowned severe storm researcher). The Enhanced F- Scale (**Table 3.66**) attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original F scale was implemented in the U.S. on February 1, 2007.

Table 3.66. Enhanced F Scale for Tornado Damage

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

Source: National Weather Service, https://www.weather.gov/oun/efscale

The Enhanced F-scale still is a set of wind estimates (not measurements) based on damage. It uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the

28 indicators listed in **Table 3.67**. These estimates vary with height and exposure. **Important**: The 3 second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

Table 3.67. Enhanced F Scale Damage Indicators

NUMBER	DAMAGE INDICATOR	ABBREVIATION
1	Small barns, farm outbuildings	SBO
2	One- or two-family residences	FR12
3	Single-wide mobile home (MHSW)	MHSW
4	Double-wide mobile home	MHDW
5	Apt, condo, townhouse (3 stories or less)	ACT
6	Motel	M
7	Masonry apt. or motel	MAM
8	Small retail bldg. (fast food)	SRB
9	Small professional (doctor office, branch bank)	SPB
10	Strip mall	SM
11	Large shopping mall	LSM
12	Large, isolated ("big box") retail bldg.	LIRB
13	Automobile showroom	ASR
14	Automotive service building	ASB
15	School - 1-story elementary (interior or exterior halls)	ES
16	School - jr. or sr. high school	JHSH
17	Low-rise (1-4 story) bldg.	LRB
18	Mid-rise (5-20 story) bldg.	MRB
19	High-rise (over 20 stories)	HRB
20	Institutional bldg. (hospital, govt. or university)	IB
21	Metal building system	MBS
22	Service station canopy	SSC
23	Warehouse (tilt-up walls or heavy timber)	WHB
24	Transmission line tower	TLT
25	Free-standing tower	FST
26	Free standing pole (light, flag, luminary)	FSP
27	Tree - hardwood	TH
28	Tree - softwood	TS

Source: National Weather Service, www.spc.noaa.gov/faq/tornado/ef-scale.html

Figure 3.123 illustrates the total number tornadoes per U.S. County between 1955 and 2014. Counties within Missouri have recorded between 1 and 60 tornadoes during this nearly 59-year period. None of the counties within Missouri reported zero tornado events.

Figure 3.123. Tornado Activity in the United States

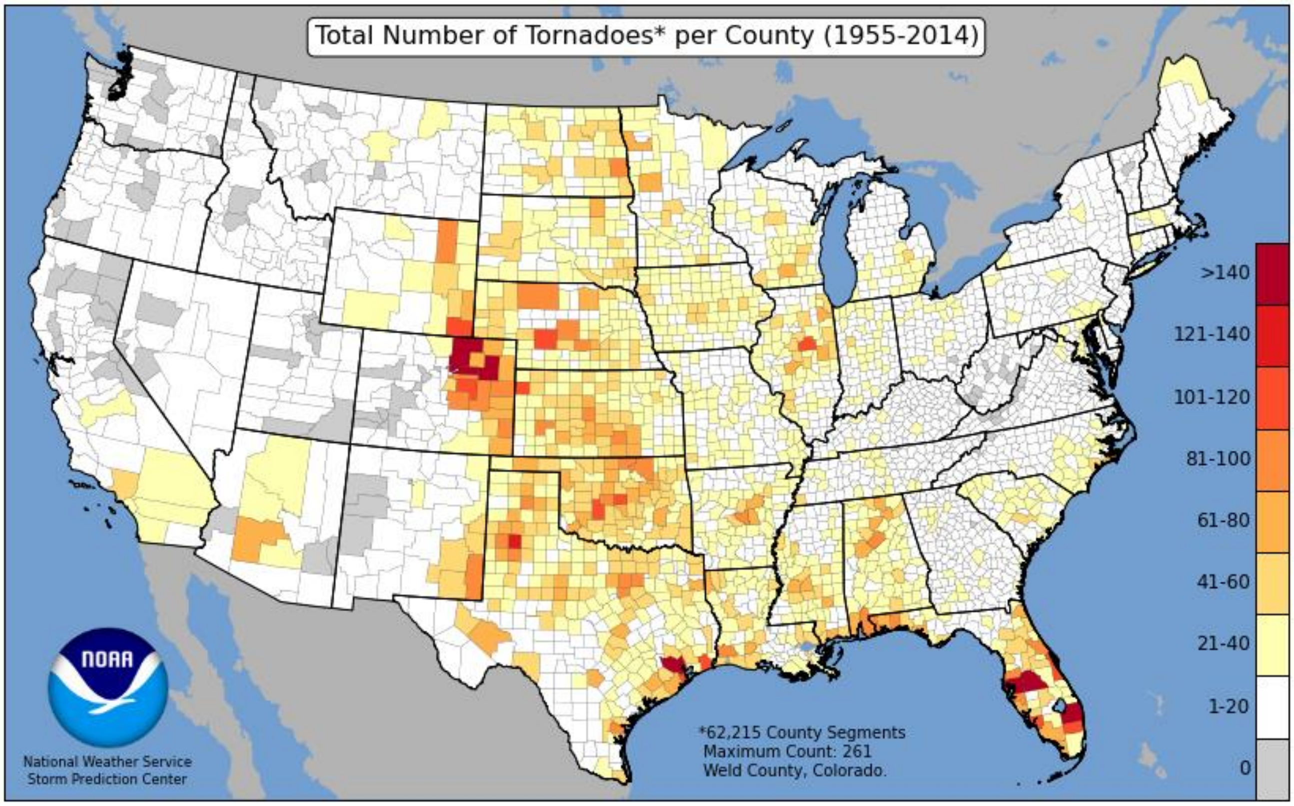


Table 3.68 reports the percentage of Missouri Tornadoes by F-Scale, 1950–2021.

Table 3.68. Missouri Tornadoes by F-Scale, 1950–2021

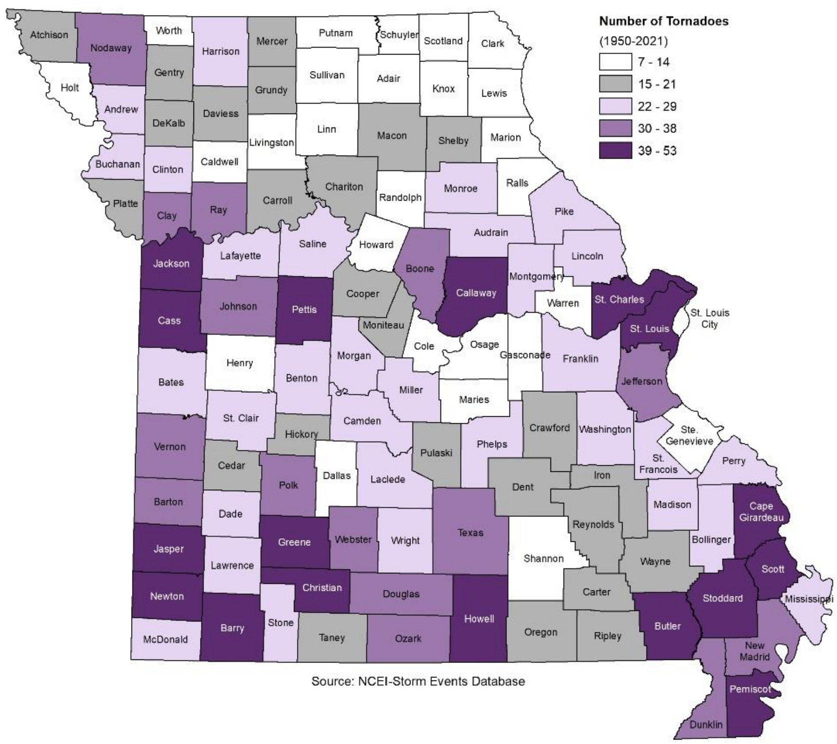
Scale	Percentage
F0	36.7%
F1	38.3%
F2	16.7%
F3	5.9%
F4	2.3%
F5	0.07%

Source: NCEI Storm Events Database, https://www.ncdc.noaa.gov/stormevents/

Previous Occurrences

Historically, Missouri has experienced numerous tornadoes of varied intensities. The National Centers for Environmental Information reports that 2,772 tornadoes occurred in Missouri from 1950 to December 31, 2021, with 402 deaths and over $5.3 billion in damage. See **Figure 3.124** for the historical number of tornadoes in Missouri by county. Descriptions of significant tornado events are provided in the following paragraphs.

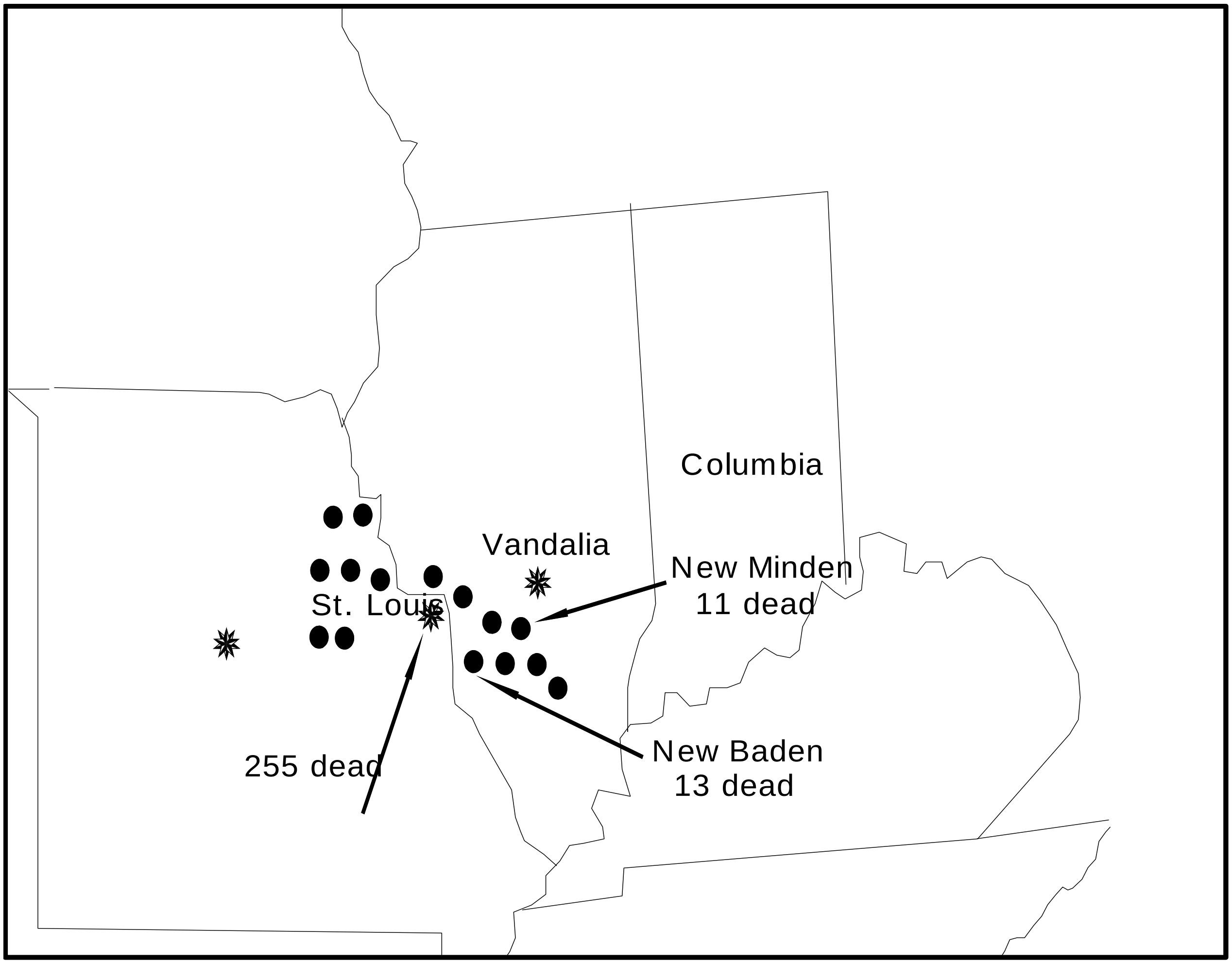
Figure 3.124. Historical Number of Tornadoes in Missouri



Source: NCEI-Storm Events Database

On **May 27, 1896**, between the hours of 2 and 8 p.m., a series of 18 tornadoes known as the “St. Louis, Missouri, Outbreak” struck Missouri and Illinois. These tornadoes resulted in 306 deaths and $15 million in damage (see **Figure 3.125**).

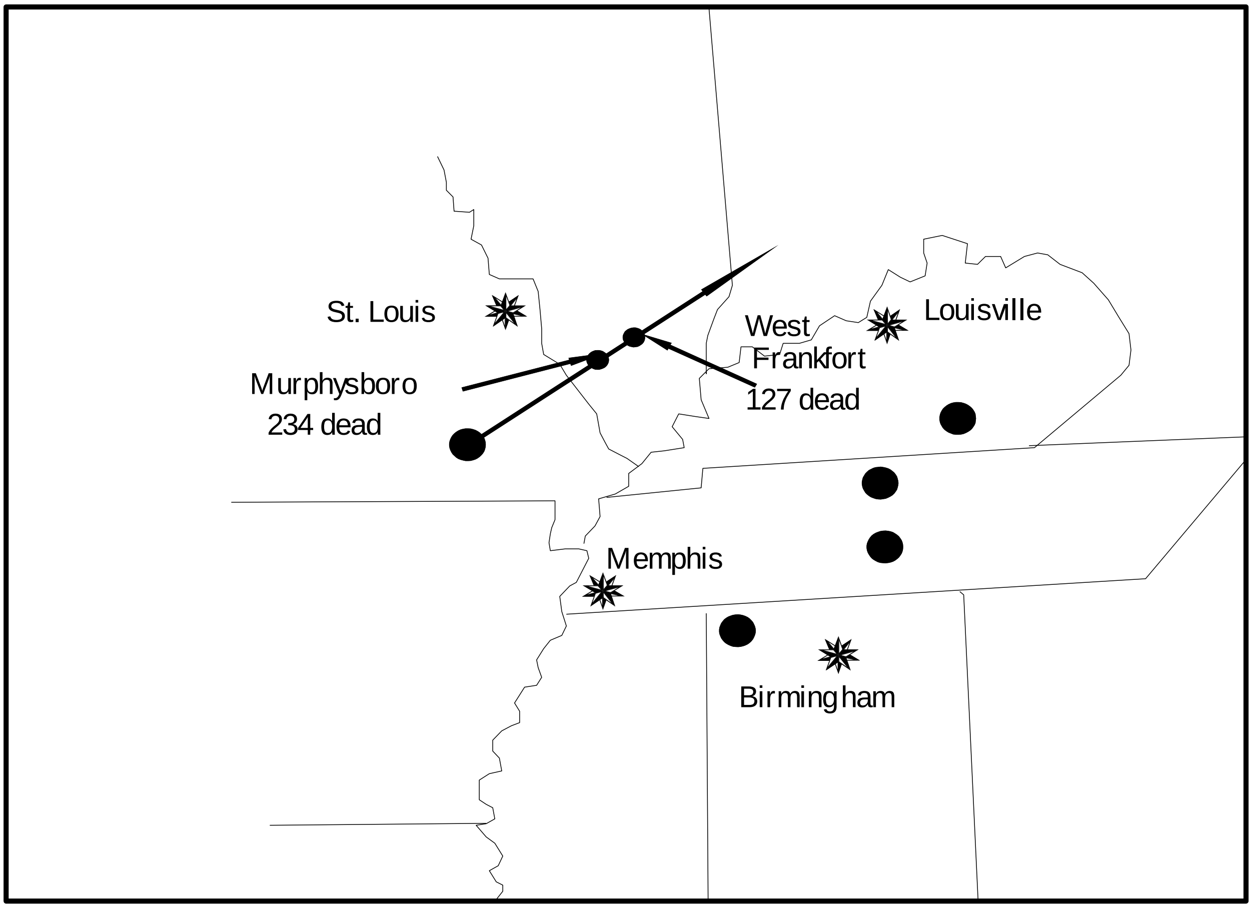
Figure 3.125. St. Louis, Missouri, Tornado Outbreak of 1896



Source: State Hazard Analysis, October 2009

The worst tornado in U.S. history, in terms of deaths and destruction, occurred in Missouri on **March 18, 1925**, between 1 and 6 p.m. (see **Figure 3.126**). The great "tri-state" tornado originated in Reynolds County, and it proceeded east-northeast through the southern quarter of Illinois and into Indiana, covering 219 miles. It caused over $18 million in damage, affected six states, and killed 689 people.

Figure 3.126. The Great Tri-State Tornado of 1925



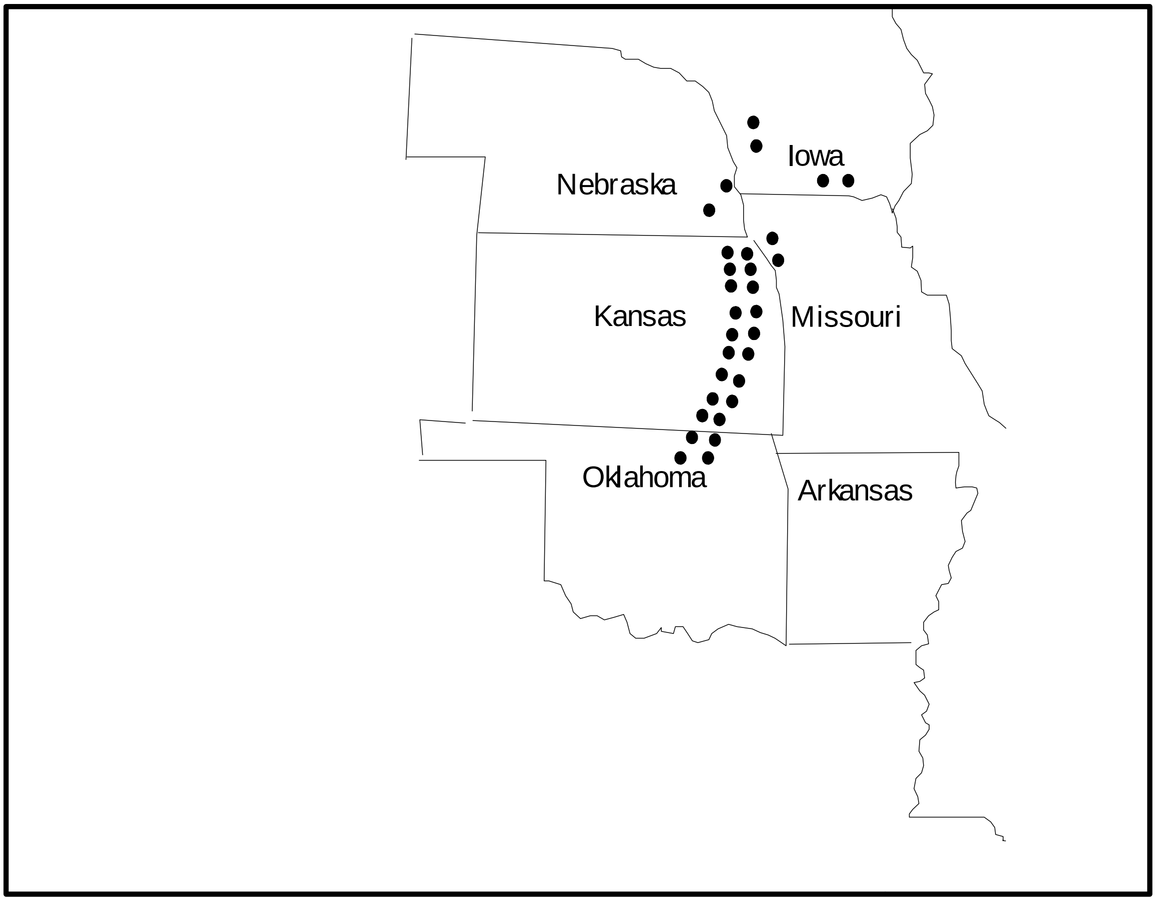
Source: State Hazard Analysis, October 2009

The City of Poplar Bluff, Missouri, was almost wiped out by a tornado on **May 9, 1927**. This tornado took 92 lives and caused an estimated $2 million in damage. The same day, two severe tornadoes struck St. Louis, Missouri. The first tornado moved across the entire city from the western city limits to the Mississippi River through the Lafayette Park area, killing 306 people in Missouri and Illinois and causing almost $13 million in damage. The second tornado started in the southwestern part of the City and proceeded through the Tower Grove and Vanderventer areas, then on to Granite City, Illinois. Seventy-nine people were killed, and about $23 million in damage resulted from this storm.

On **May 20, 1957**, an F-5 tornado hit Jackson County causing major damage in the Ruskin Heights area. According to NCEI, the tornado caused 37 deaths, 176 injuries and $2.5 million in damages as it carved a path ranging from one-tenth to nearly one-half mile wide and sped northeast at approximately 42 miles per hour.

During the afternoon and evening of April 3, and the early morning of **April 4, 1974**, a "super outbreak" of 148 tornadoes across 13 states killed more than 300 people, injured more than 6,000 and caused $600 million in damage (see **Figure 3.127**).

Figure 3.127. The Tornado Super Outbreaks in 1974



Source: State Hazard Analysis, October 2009

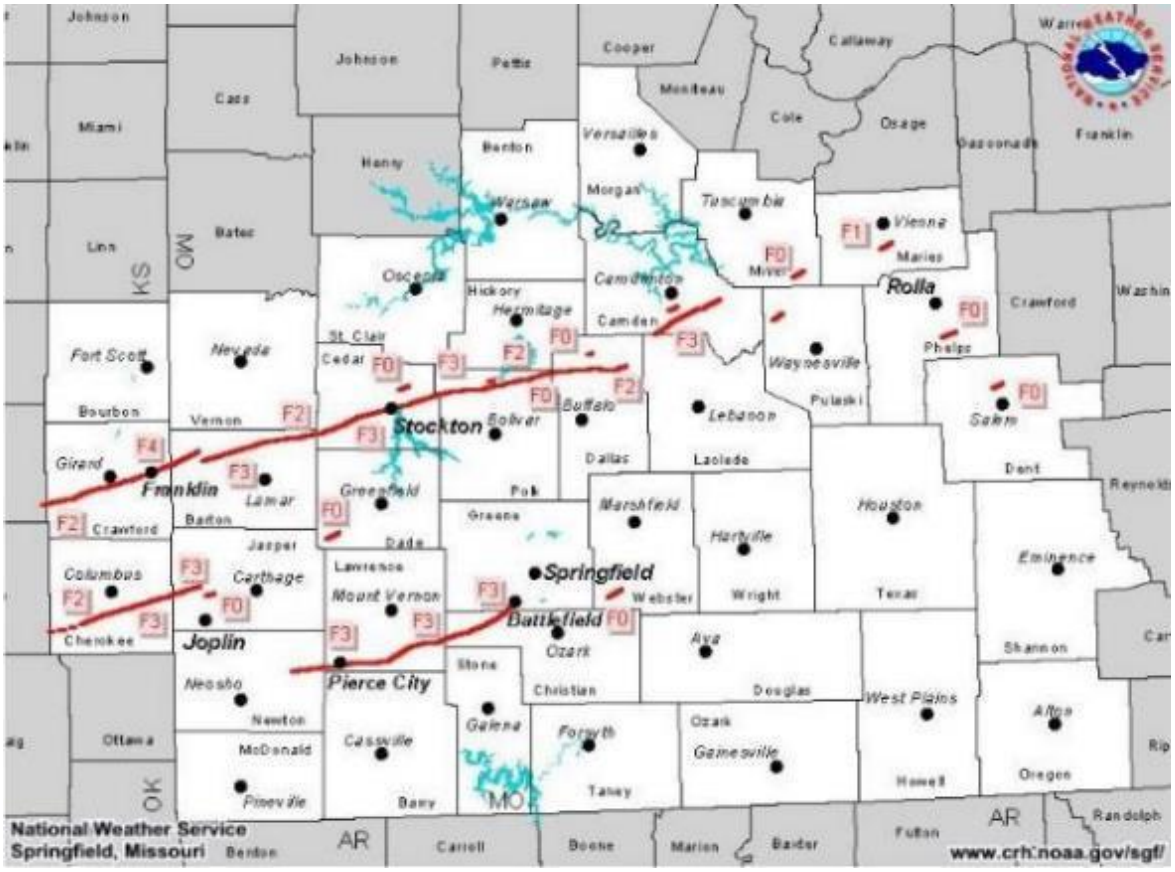
On the afternoon of April 26, and the early morning of **April 27, 1991**, an outbreak of 54 tornadoes covering six states, including Missouri, resulted in 21 deaths, 308 injuries, and damage exceeding $277 million. There were two deaths in vehicles and 15 deaths in and near mobile homes.

On **July 4, 1995**, at approximately 5:40 p.m., a tornado struck the Randolph County community of Moberly. The initial touchdown of the storm was south of town. The storm then moved through the eastern half of the community. The tornado uplifted approximately 7 miles northeast of Moberly. At least 15 people were injured, 25 businesses damaged, along with the courthouse, and some 300 families affected. This resulted in a Small Business Administration disaster declaration for low interest loans. The tornado was characterized by the National Weather Service as an F3 tornado.

A record 84 tornadoes were recorded in Missouri in 2003. During the week of **May 4, 2003**, 79 of those tornadoes occurred, mostly in the southwest portion of Missouri. There were several F4 tornadoes on May 4 in Platte, Clay, and Barton Counties. There were nineteen people killed by the tornadoes in southwest Missouri. That is the highest total since 1959 when 21 were killed. It is only the fourth year in which double-digit deaths from tornadoes occurred in Missouri since 1950. The killer tornadoes all occurred on May 4, 2003 (see **Figure 3.128**). The tornadoes that hit Newton, Lawrence, Christian, and Greene Counties killed seven people. Five people were killed by a tornado that hit Cedar and Dallas Counties. A tornado that hit Camden County killed four people, two people died from a tornado in

Jasper County, and one person died in Barton County. The tornadoes injured 171 people. That is the highest total since 1957 when 310 people were injured. This information was provided by the National Weather Service.

Figure 3.128. Map of the May 4, 2003, Tornadoes



Source: National Weather Service, https://www.weather.gov/ohx/20030504

On **May 29, 2004**, nine tornadoes touched down in northern and western Missouri. The strongest, an F4, struck just east of Weatherby in DeKalb County, destroying homes and killing three people.

The year 2006 was a record year for tornadoes and severe weather outbreaks for Missouri. There were 102 tornadoes recorded which surpassed the previous record year of 2003 when 84 tornadoes were recorded. Four sets of major storms went through the State: March 8–13 (DR-1631), March 30–April 2 (DR-1635), July 19–21 (EM-3267 and DR-1667), and September 22–23 tornado damages

Between the two March/April storms, which both received declarations for severe storms, tornadoes, and flooding, 44 tornadoes touched down in Missouri. Fourteen people were killed (making it the fifth year in which double-digit deaths from tornadoes occurred in Missouri since 1950), 147 were injured, 646 homes were destroyed, 3,678 homes were damaged, and 1,134 homes were affected. As of June 14, 2006, Missouri citizens had received more than $32 million in federal recovery assistance. As a result of the first round of storms, 41 counties received major disaster declarations. Also, there was an estimated $5.6 million in damages from these tornadoes reported by four Missouri Electrical Cooperatives. The second round of storms resulted in major disaster declarations for seven counties. In

Pemiscot County, 100 percent of Braggadocio, 80 percent of Deering, and over 60 percent of Caruthersville were destroyed. Major problems included drinking water, utilities, debris removal, and shelter and housing.

On **September 22, 2006**, another series of severe storms and tornadoes swept across the State and destroyed over 600 residences and 75 businesses in 12 counties. The National Weather Service confirmed an F4 tornado in Perry County. Also, there was an estimated $986,000 in damages reported by nine Missouri Electrical Cooperatives from the tornadoes.

In 2007, there were 45 tornadoes recorded by the NCEI database causing $2.133 million in property damages, three fatalities, and five injuries. There were no federal declarations for tornado damages, but several notable tornadoes. An overnight series of tornadoes started February 28th and continue through the night into March 1st and crossed the State. A total of nine tornadoes did approximately $880,000 damage in Bates, Henry, Cass, Johnson, Monroe, Shelby, Ozark, and Howell Counties.

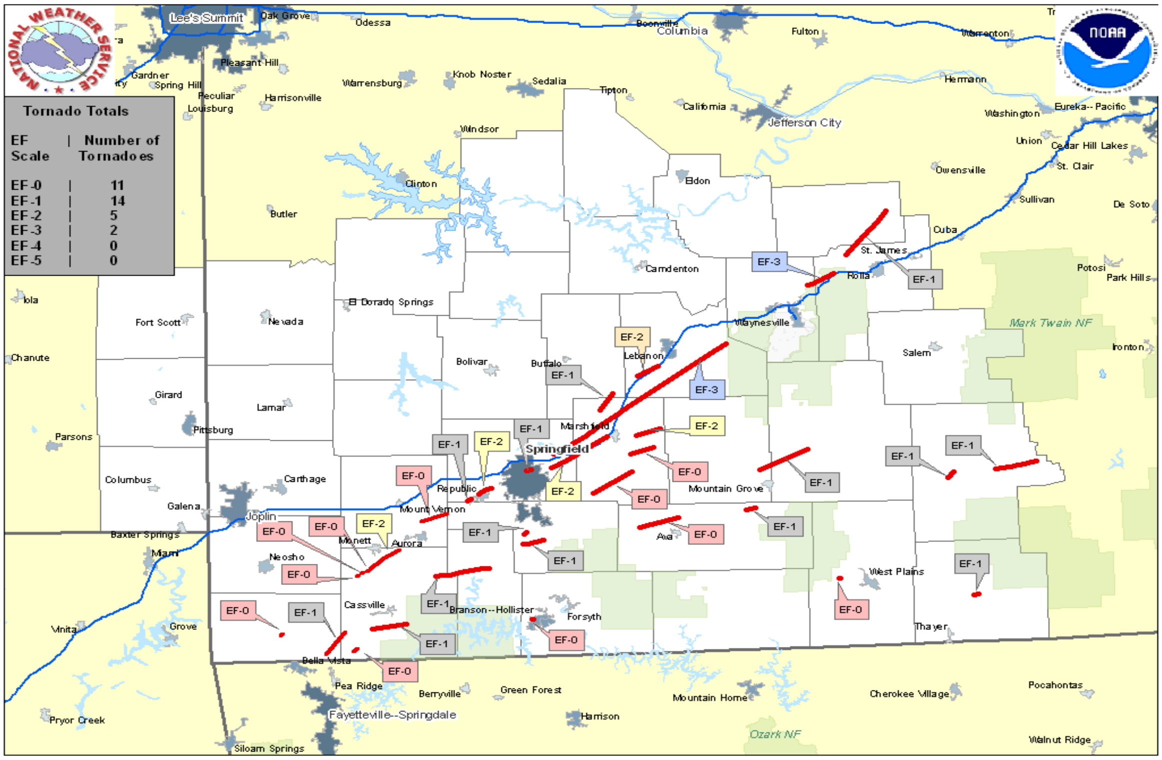
On **October 17, 2007**, a cold front initiated severe thunderstorms producing isolated tornadoes during the early evening hours through early morning of October 18th. Most of the damage occurred in rural eastern Lawrence County to five houses, a dairy barn, and a sawmill. More damage to homes, trees, corn crop, and a machine shed were recorded in Greene, Johnson, Laclede, Callaway, and Monroe Counties.

In 2008, there were 103 tornadoes recorded by the NCEI database with 242 injuries, 19 fatalities, $97.9 million in property damages and producing three federal disasters in Missouri.

A tornado outbreak on **January 7-8, 2008 (DR-1742**) was an unusually early severe weather outbreak hit the Missouri Ozarks Monday afternoon, January 7th, into the early morning hours Tuesday, January 8th, 2008. Numerous supercell thunderstorms spawned at least 29 tornadoes that resulted in significant damage to homes, trees and power lines. The supercell thunderstorms were followed by a violent squall line that produced damaging straight-line winds in excess of 70 mph. In addition, the storms produced torrential rainfall and flash flooding. The storms developed as an intense storm system tracked out of the Rockies and interacted with an unseasonably warm, moist and unstable air mass across the Ozarks. **Figure 3.129** shows the paths of the tornadic events on January 7-8, 2008.

The National Weather Service in Springfield, Missouri issued 33 severe thunderstorm warnings and 62 tornado warnings in approximately a 12-hour period. A total of 161 severe weather reports were received from mid-afternoon on January 7th through the early morning hours on January 8th.

Figure 3.129. Tornado Path on January 7-8, 2008

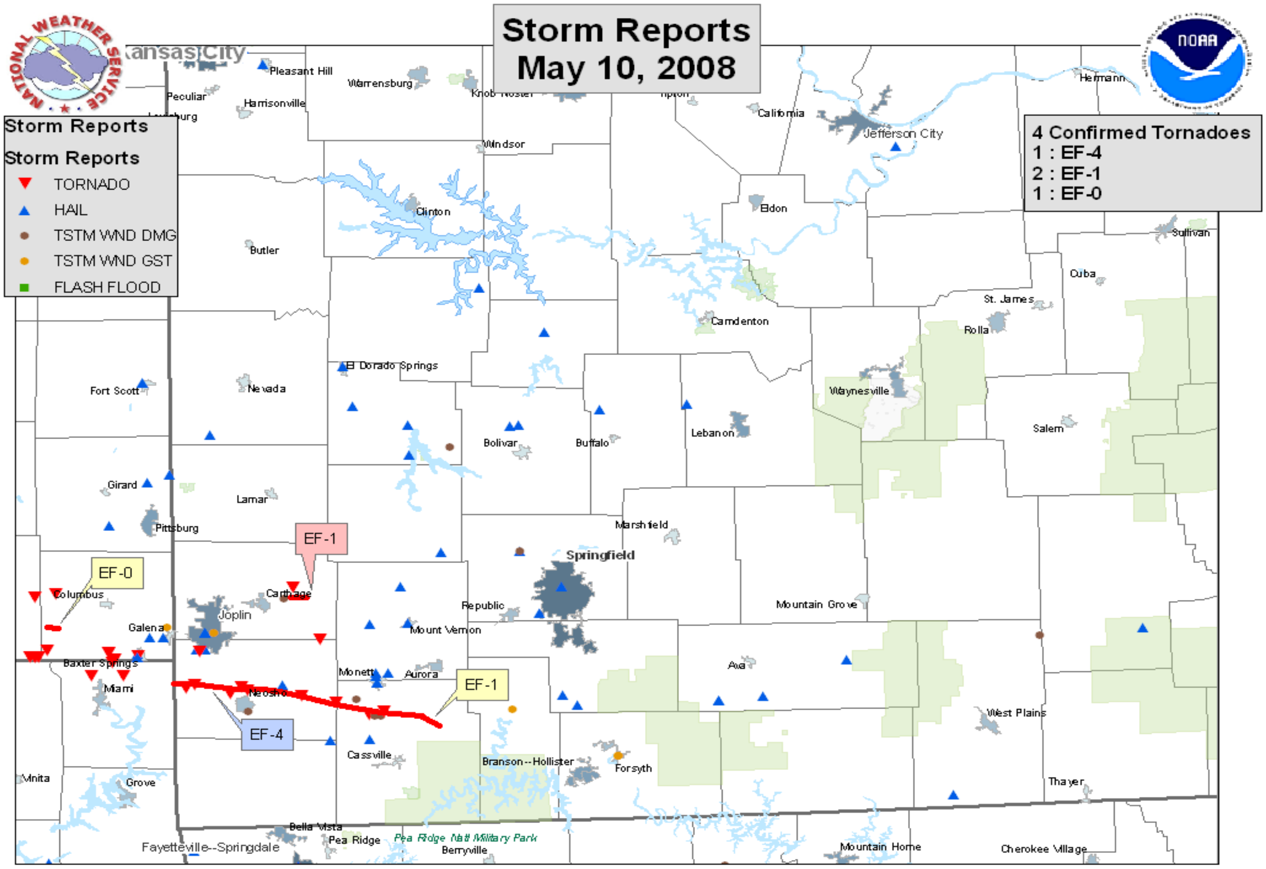


Source: National Weather Service, https://www.weather.gov/sgf/events_2008jan7

May 10, 2008 (DR-1760)--A strong area of low pressure lifted northeast out of southwest Missouri and into central Missouri during the evening. Instability increased over southeast Kansas and the southwest corner of Missouri during the late afternoon as temperatures rose into the mid to upper 70s. The instability along with the strong cold front caused severe thunderstorms to develop. With strong wind shear in the area, the storms in this area quickly became tornadic along with producing large hail to the size of softballs. The tornadic storms were mainly concentrated in an area from Cherokee County, Kansas to Newton and Barry Counties in Missouri. **Figure 3.130** shows the paths of the tornadic events on January 7-8, 2008.

These storms moved into southwest Missouri causing devastating damage to homes, businesses, and trees in Newton, Barry, and Jasper Counties. One tornado, with an intensity that ranged from EF-4 to EF-1, killed 15 people as it tracked through Newton and Barry Counties, while another tornado killed one person in Jasper County. Also, there was $229,100 in estimated damages reported by two Missouri Electrical Cooperatives from the tornadoes.

Figure 3.130. Tornado Path on May 10, 2008



Source: National Weather Service, https://www.weather.gov/sgf/events_2008may10

There was one additional tornado that produced damages to be included with FEMA-DR-1809. It occurred on November 6, 2008, along the western side of Table Rock Lake near the community of Mano in Barry County. This EF-1 tornado damaged boat docks on Table Rock Lake.

May 13, 2009 (DR-1847)--During the evening of May 13, 2009, a series of powerful supercell storms developed ahead of a cold front, pushing southward out of Iowa and Nebraska. These supercell storms produced a wide array of severe weather, with large hail up to the size of golf balls and winds up to 60 mph reported. These storms marched across eastern Kansas and northern Missouri during the evening hours, with a strong supercell storm producing tornadic activity in parts of northeast Missouri. Damage surveys conducted by the National Weather Service, in conjunction with emergency management, have found evidence of three tornadoes in Sullivan and Adair Counties. All tornadoes appeared to have been produced by the same supercell thunderstorm. There were three fatalities. Moderate to severe damage was reported, in the Kirksville area. Also, there was $180,000 in estimated damages reported by three Missouri Electrical Cooperatives from the tornadoes.

May 22, 2011 (DR-1980) – From May 21st through May 26th a massive storm system stretching from Lake Superior southwest to central Texas spawned numerous tornadoes as it swept east across the country. In the late afternoon hours of May 22nd, a large, multiple-vortex tornado touched down just outside Joplin, Missouri. The Joplin tornado had recorded wind speeds of greater than 200 mph and had a maximum width of nearly a mile. The twister touched down just east of the Kansas border just north of I-44. It then

proceeded to move East and South through the city of Joplin before finally weakening and dissipating near Diamond, Missouri. All told, 158 people were killed and over 1,100 injured making this tornado the deadliest to hit the U.S. since 1947. Some 25% of Joplin had been completely demolished and estimates on insurance claims have been as high as $3 billion making it the single most costly tornado in U.S. history. In addition to the 158 dead in Missouri due to the Joplin tornado, the late may tornado outbreak killed 20 others throughout the states of Arkansas, Kansas, Minnesota, and Oklahoma. The storm system spawned a total of 242 tornados including a second EF-5 that touched down near Calumet, Oklahoma and caused significant damage throughout the Midwestern United States.

May 29 to June 10, 2013 (DR-4130) - Storms developed along an outflow boundary that was laid out along the I-70 corridor. The storms produced wind damage, large hail as well as 9 tornadoes. Two of the tornadoes were rated EF3 as they moved through the St. Louis metro area. Also, heavy rain fell causing flash flooding in some locations, which persisted into the early morning hours of June 1st. On July 3, 2013, Governor Jeremiah W. Nixon requested a major disaster declaration due to severe storms, straight-line winds, tornadoes, and flooding during the period of May 29 to June 10, 2013. The Governor requested a declaration for Individual Assistance for seven counties, Public Assistance for 30 counties, and Hazard Mitigation statewide. On July 18, 2013, President Obama declared that a major disaster exists in the State of Missouri.

September 9-10, 2014 (DR-4200) - During the afternoon and evening of September 9, 2014, a line of thunderstorms moved though eastern Nebraska into Iowa and northern Missouri. Along the southwestern edge of the line a strong supercell formed, producing widespread wind and hail across far northwestern Missouri. This supercell went on to produce 5 brief and weak tornadoes across northwestern Missouri before finally dissipating. The main line of convection then caused wind damage across northern Missouri through the remainder of the overnight hours. Another tornado then formed early in the morning on September 10 near Kirksville, Missouri. On October 22, 2014, Governor Jeremiah W. Nixon requested a major disaster declaration due to severe storms, tornadoes, straight-line winds, and flooding during the period of September 9-10, 2014. The Governor requested a declaration for Public Assistance for 20 counties and Hazard Mitigation statewide. On October 31, 2014, President Obama declared that a major disaster exists in the State of Missouri.

May 15 to July 27, 2015 (DR-4238) - A strong upper-level system moved through the Midwest region and produced a squall line of thunderstorms across the Missouri Ozarks. This squall line of storms produced numerous reports of wind damage and a few weak tornadoes. On July 21, 2015, Governor Jeremiah W. Nixon requested a major disaster declaration due to severe storms, tornadoes, straight-line winds, and flooding during the period of May 15 to July 27, 2015. The Governor requested a declaration for Individual Assistance for 15 counties, Public Assistance for 68 counties, and Hazard Mitigation statewide. On August 7, 2015, President Obama declared that a major disaster exists in the State of Missouri.

December 23, 2015, to January 9, 2016 (DR-4250) - Two fast-moving lines of strong to severe storms moved east across southeast Missouri, accompanied by strong winds and isolated tornadoes. The tornado began near the Current River along Highway Z and then moved northeast. Hundreds of trees were snapped or uprooted within a well-defined path in the Ozark National Scenic Riverways. On January 21, 2016, President Barack Obama granted Governor Jay Nixon's request for a major disaster declaration for Missouri.

Table 3.69 The table summarizes Missouri tornado statistics from 1950 through 2021.

Table 3.69. Missouri Tornado Statistics, 1950–2021

Total Number of Tornadoes	2,772
Total Number of Deaths	402
Total Number of Injuries	4,489
Yearly Average of Tornadoes	38.5
Yearly Average of Deaths	5.6
Yearly Average of Injuries	62.3

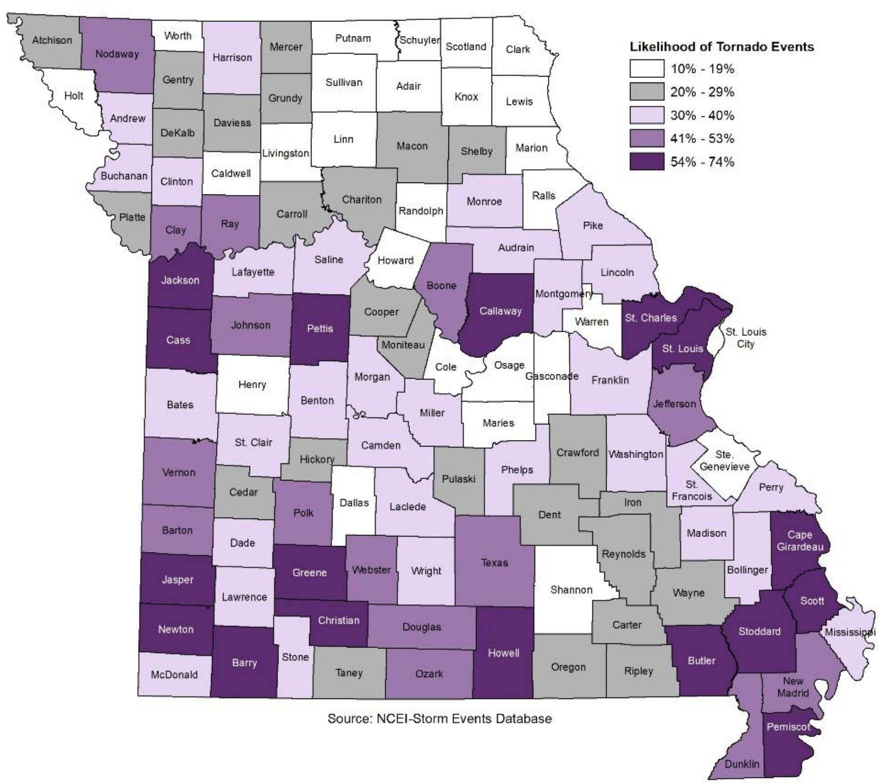
Source: NCEI Storm Events Database, https://midsouthtornadoes.msstate.edu/index.php?cw=lsx

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of tornado damages for the ten-year period of 2012 – 2021 totaled $22,664.

Probability of Future Hazard Events

The United States has 10 times more tornadoes than any other nation in the world. Missouri averages 38.5 tornadoes per year and has recorded 2,772 tornadoes between 1950 and December 31, 2021. Missourians have a 100% probability that tornadoes will continue to affect their lives.

Figure 3.131. Average Annual Occurrence for Tornadoes



Changing Future Conditions Considerations

Scientists do not know how the frequency and severity of tornadoes will change. Research published in 2015 suggests that changes in heat and moisture content in the atmosphere, brought on by a warming world, could be playing a role in making tornado outbreaks more common and severe in the U.S. The research concluded that the number of days with large outbreaks have been increasing since the 1950s and that densely concentrated tornado outbreaks are on the rise. It is notable that the research shows that the area of tornado activity is not expanding, but rather the areas already subject to tornado activity are seeing the more densely packed tornadoes. Because Missouri experiences on average around 38.5 tornadoes a year, such research is closely followed by meteorologists in the state.

State Vulnerability Overview

Every tornado is a potential killer, and many are capable of great destruction. Tornadoes can topple buildings, roll mobile homes, uproot trees, hurl people and animals through the air for hundreds of yards, and fill the air with lethal, windblown debris. Sticks, glass, roofing material, and lawn furniture all become deadly missiles when driven by tornado winds. In 1975, a Mississippi tornado carried a home freezer for more than a mile. Once, a tornado in Broken Bow, Oklahoma, carried a motel sign 30 miles and dropped it in Arkansas. Tornadoes do their destructive work through the combined action of their strong rotary winds and the impact of windblown debris. In the simplest case, the force of the tornado's winds pushes the windward wall of a building inward. The roof is lifted up, and the other walls fall outward. Until recently, this damage pattern led to the incorrect belief that the structure had exploded as a result of the atmospheric pressure drop associated with the tornado.

The method used to determine vulnerability to tornadoes across Missouri was statistical analysis of data from several sources: HAZUS building exposure value data, population density and mobile home data from the U.S. Census (2019), the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina, and storm events data (1950 to December 31, 2021) from the National Centers for Environmental Information (NCEI). It is important to realize that one limitation to the NCEI data is that many tornadoes that might have occurred in uninhabited areas, as well as some in inhabited areas, may not have been reported. The incompleteness of the data suggests that it is not appropriate for use in parametric modeling. In addition, NOAA data cannot show a realistic frequency distribution of different Fujita scale tornado events, except for recent years. Thus, a parametric model based on a combination of many physical aspects of the tornado to predict future expected losses was not used. The statistical model used for this analysis was probabilistic based purely on tornado frequency and historic losses. It is based on past experience and forecasts the expected results for the immediate or extended future.

From the statistical data collected, six factors were considered in determining overall vulnerability to tornadoes as follows: building exposure, population density, social vulnerability, percentage of mobile homes, likelihood of occurrence, and annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. Once the ranges were determined and applied to all factors considered in the analysis, the ratings were combed to determine an overall vulnerability rating for tornadoes. These rating values correspond to the following descriptive terms:

6) Low
7) Medium-Low
8) Medium

9) Medium-High
10) High

All county-level statistical data tables, including ranges for vulnerability factor ratings, are presented in Appendix A. **Figure 3.132** presents the percentage of mobile homes per county in 2019. **Figure 3.133** present the vulnerability summary for tornado events.

Figure 3.132. Percent of Mobile Homes per County

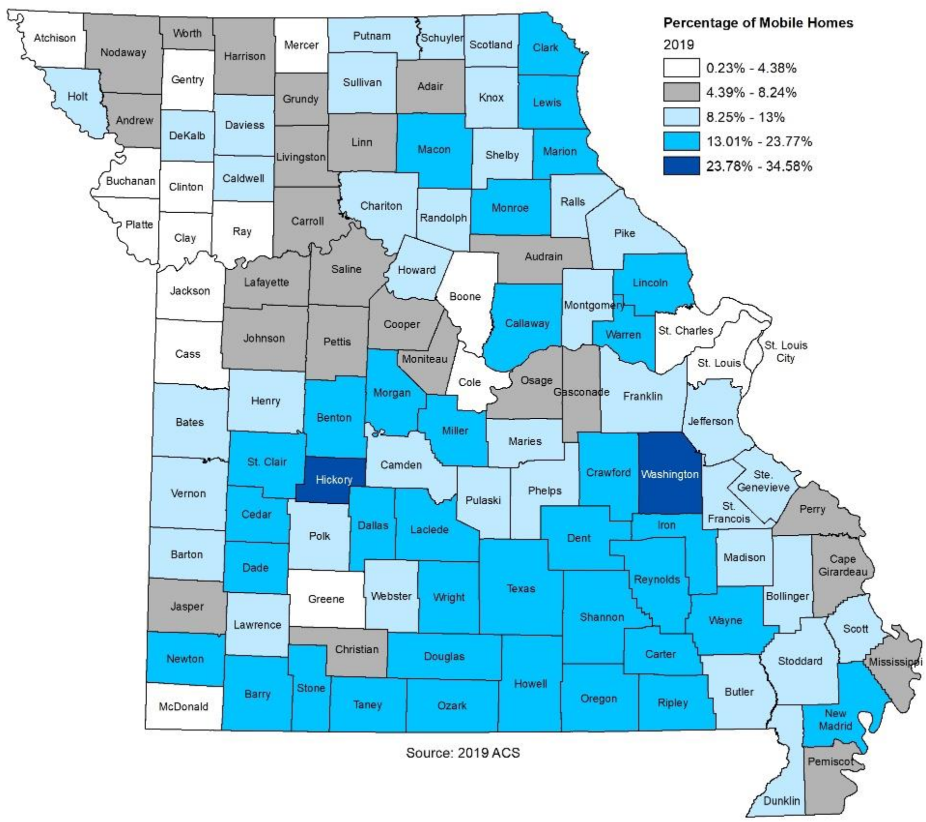
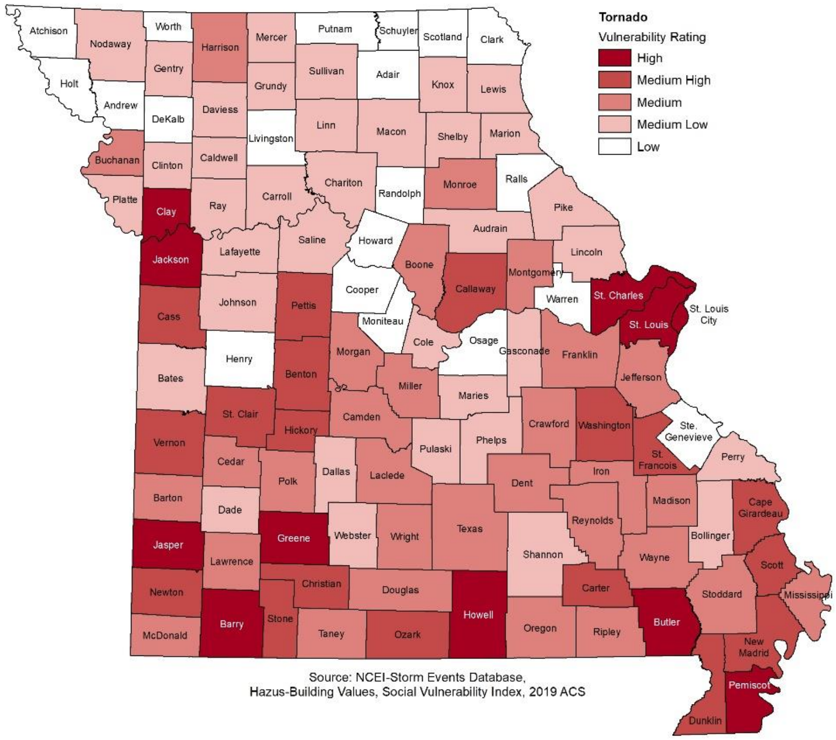


Figure 3.133. Overall Vulnerability to Tornadoes



State Estimates of Potential Losses

From the statistical data collected, annualized historical losses from 1950 to December 31, 2021, were considered in determining annualized tornado damages. See **Figure 3.134** for historical losses by County.

Figure 3.134. Annualized Property Loss for Tornadoes

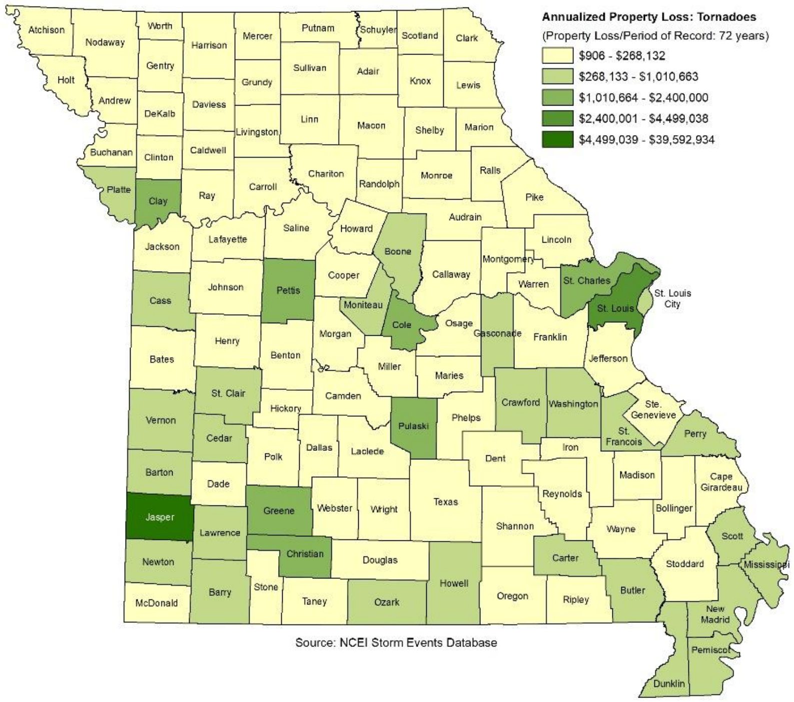
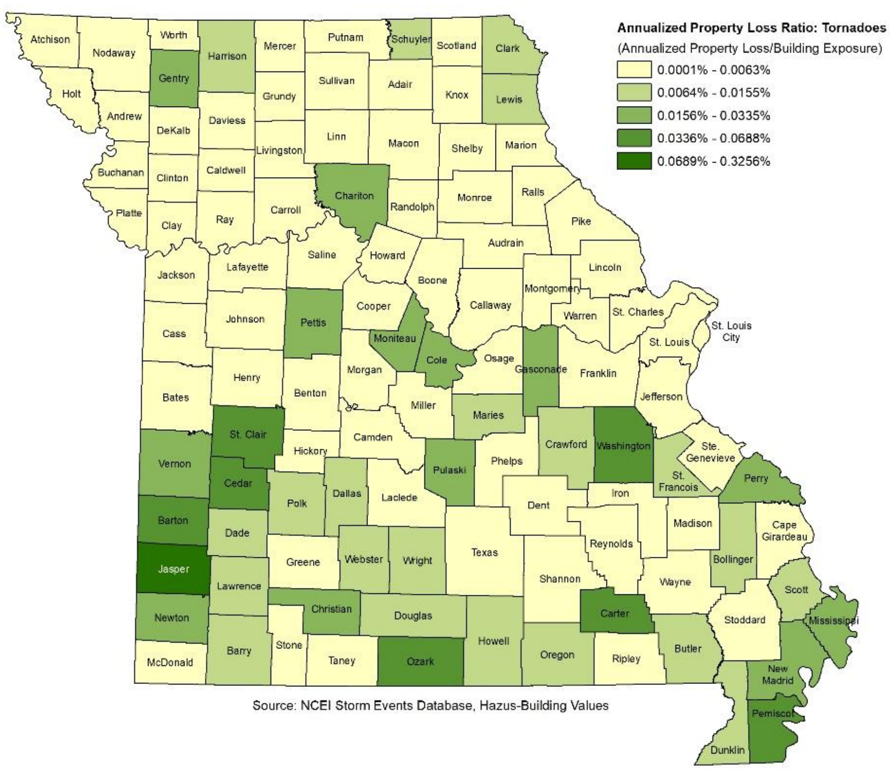


Figure 3.135. Annualized Property Loss Ratio for Tornadoes



Hazard Impact on Future Growth and Development

Ten counties rated "High" in overall vulnerability to Tornado: Barry, Butler, Clay, Greene, Howell, Jackson, Jasper, Pemiscot, St. Charles, and St. Louis, as well as, the City of St. Louis. Of these counties and city, Barry, Clay, Greene, Jackson, and St. Charles are experiencing population growth. With growing population and increased development, there is potential for increased losses as a result of the increase in exposure. But this will be dependent on where the severe thunderstorms occur, which is a variable that cannot be predicted due to the random nature of this hazard.

Risk Summary

The potential severity of effects from tornadoes will continue to be high. We will continue to experience deaths, injuries, and property damage from tornadoes. However, technological advances will facilitate earlier warnings than previously available. This, combined with a vigorous public education program and improved construction techniques, provides the potential for significant reductions in the number of deaths and injuries, as well as reduced property damage.

Problem Statement:

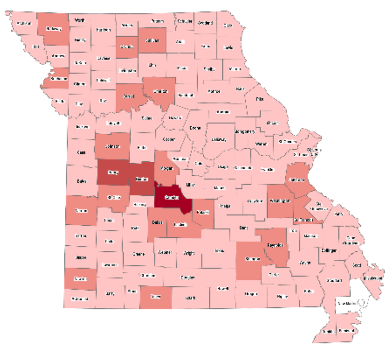
Using Overall Vulnerability to Tornado as a key indicator, the most vulnerable counties are Barry, Butler, Clay, Greene, Howell, Jackson, Jasper, Pemiscot, St. Charles, and St. Louis, as well as, the City of St. Louis. Mitigation efforts and dollars allocated, especially for saferooms, in these areas would likely be of the most benefit.

2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.11. Wildfire

Description

A wildfire is an unplanned fire that burns in a natural area such as a forest, grassland, or prairie. The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from the destructive effects of wildfires. Each year, an average of about 3,059 wildfires burn more than 49,280 acres of forest and grassland in Missouri. Most of the fires occur during the spring season, normally between February 15 and May 10. The length and severity of burning periods largely depend on the weather conditions.

Vulnerability	Extent/Range of Intensity
	Wildfire events can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating. A wildfire has the potential to kill people, livestock, fish and wildlife. The severity in Missouri is considered low to moderate.

Probability	Severity	Location
100%, 3,059 wildfire events per year average	Low to Moderate	Statewide

State Vulnerability Overview

With over 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area. Although the National Fire Incident Reporting System does capture data on wildfires, it was determined that the Department of Conservation historical wildfire data was the best resource. The Department of Conservation data has more individual events recorded per county. Therefore, this data appeared to be more comprehensive. From the Department of Conservation wildfire data from 1993 to 2021, it was determined that the average annual number of wildfires in Missouri was 3,059 burning an average annual 49,280 acres.

Changing Future Conditions Considerations

Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and changing future conditions are also likely to increase the damage from insects and diseases. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover about one-third of the state, dominated by oak and hickory trees. As the climate changes, the abundance of pines in Missouri's forests is likely to increase, while the population of hickory trees is likely to decrease.

Risk Summary/Problem Statement

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. Wildfires may also be a cascading or secondary impact of another hazard such as earthquakes or tornadoes, as a result of damaged gas lines. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural fires.

Description/Location

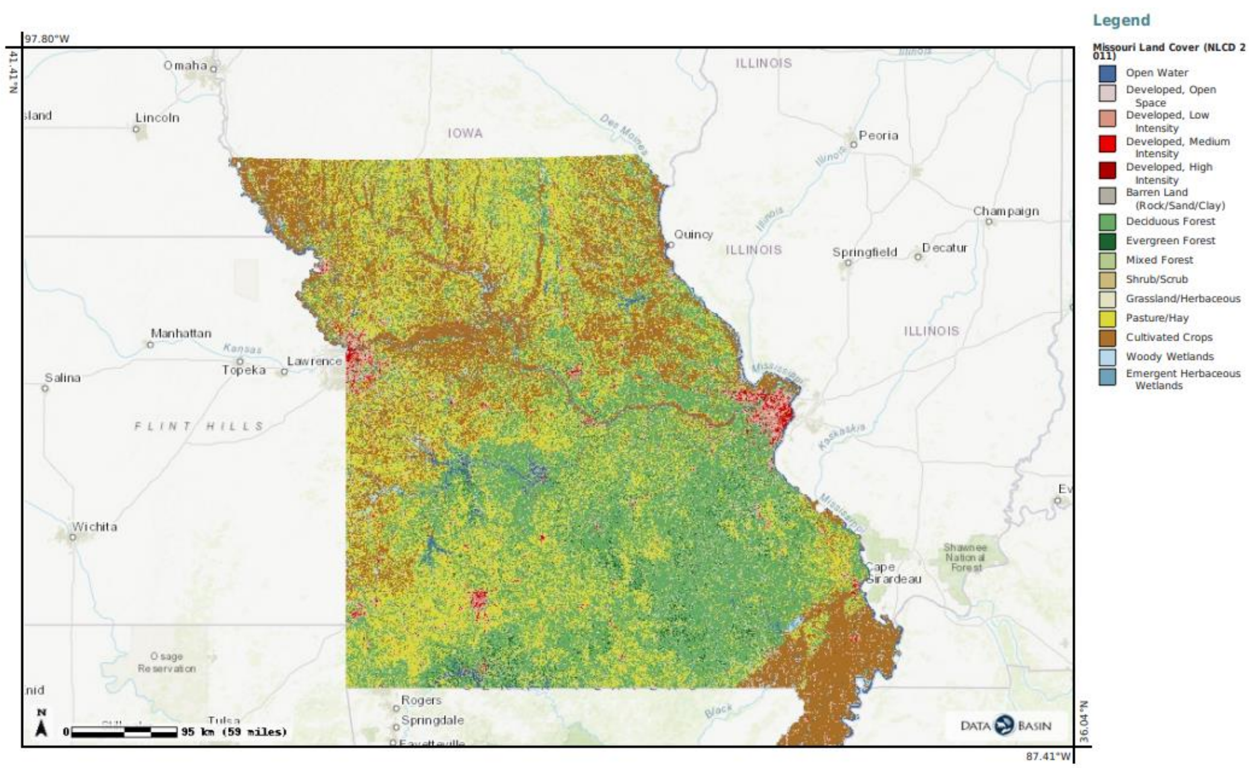
Fires can range in scope to include structural fires, urban fires, and wildfires. Urban/Structural fires are presented in **Section 3.3.14**. For the purpose of this analysis, wildfires include forest, prairie, and grassland locations. An example of wildfire is provided in **Figure 3.136**.

Figure 3.136. Wildfire in Camden County, March 2022

Source: http://www.kjluradio.com

The national land cover database (NLCD 2011) presents the location of forested areas (deciduous, evergreen, and mixed) in the central and southern areas of Missouri (shaded green areas).

Figure 3.137. Missouri Land Cover



Source: NLCD, 2011 https://databasin.org/datasets/0675b681641048a8bb4fee0fae0e78fe/

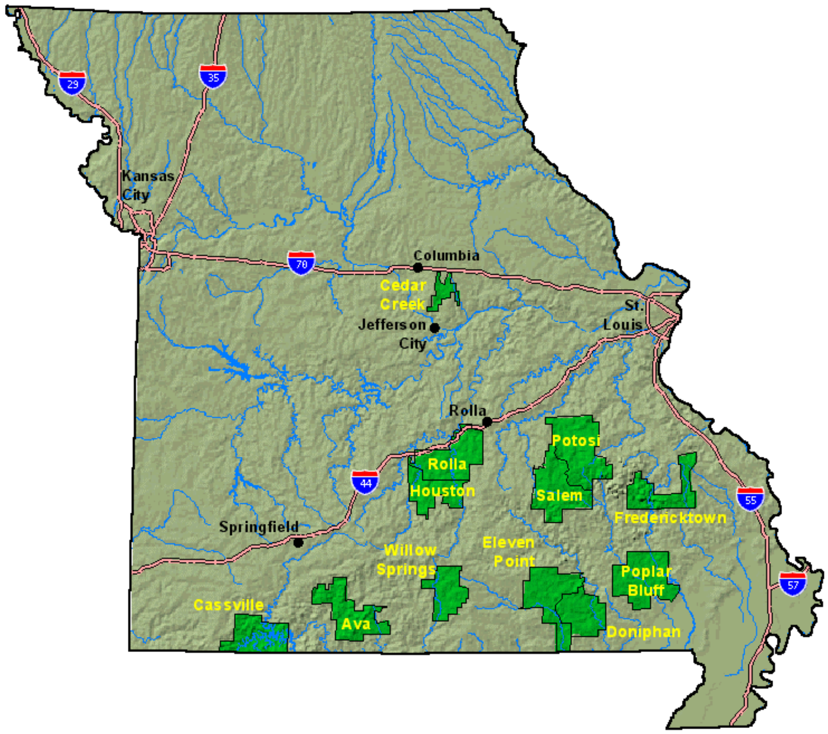
The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from the destructive effects of wildfires. To accomplish this task, eight forestry regions have been established in the State to assist with the quick suppression of fires (see Figure 3.138). The Forestry Division works closely with volunteer fire departments and federal partners to assist with fire suppression activities. Currently, approximately 700 rural fire departments have regional mutual aid agreements and over 300 have mutual aid agreements with the State to obtain assistance in wildfire protection if needed; a cooperative agreement with the Mark Twain National Forest is renewed annually. Figure 3.139 illustrates the Mark Twain National Forests across Missouri.

Forest and grassland fires can occur any day throughout the year. Each year, an average of about 3,059 wildfires burn more than 49,280 acres of forest and grassland in Missouri. Most of the fires occur during the spring season, normally between February 15 and May 10. The length and severity of burning periods largely depend on the weather conditions. Spring in Missouri is noted for its low humidity and high winds. These conditions, together with below-normal precipitation and high temperatures, result in extremely high fire danger. In addition, due to the continued lack of moisture throughout many areas of the State, conditions are likely to increase the risk of wildfires. Drought conditions can also hamper firefighting efforts, as decreasing water supplies may not provide for adequate firefighting suppression. Spring is when many rural residents burn their garden spots, brush piles, and other areas. Some landowners also believe it is necessary to burn their forests in the spring to promote grass growth, kill ticks, and reduce brush. Therefore, with the possibility of extremely high fire dangers and the increased opportunities for fires, the spring months are the most dangerous for wildfires. The second most critical period of the year is fall. Depending on the weather conditions, a sizeable number of fires may occur between mid-October and late November.

Figure 3.138. Missouri Department of Conservation Forestry Regions

Source: Missouri Department of Conservation; https://mdc.mo.gov/regions

Figure 3.139. Mark Twain National Forests



Source: Missouri Department of Conservation

In north and west-central Missouri, the MDC has limited firefighting forces. Forestry Division personnel, however, provide training and limited federal excess equipment to the many volunteer rural fire departments. See **Figure 3.138** for a map of the MDC forestry regions.

Extent /Range of Intensity

Wildfire events can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating. A wildfire has the potential to kill people, livestock, fish and wildlife. The severity in Missouri is considered low to moderate.

Wildfires often destroy property, valuable timber, forage and recreational and scenic values. In addition to the risk wildfires pose to the general public and property owners, the safety of firefighters is also a concern. Although loss of life among firefighters does not occur often in Missouri, it is always a risk. More common firefighting injuries include falls, sprains, abrasions or heat-related injuries such as dehydration. Response to wildfires also exposes emergency responders to the risk of motor vehicle accidents and can place them in remote areas away from the communities that they are chartered to protect.

Previous Occurrences

At the present time, the forestry districts provide fire protection to approximately one-half of the State, or about 16 million acres. Within these districts, fairly accurate forest and grassland fire statistics are available from the MDC. In a typical year, approximately 3,059 wildfires occur.

During the past 5 years, 11,696 wildfires occurred in Missouri, burning 178,735 acres. Debris burning (fires resulting from land clearing, burning trash, range, stubble, right-of-way, logging slash, etc.) is the major identifiable cause of forest and grass fires in Missouri. Other significant causes are unknown, miscellaneous, equipment, and arson.

Table 3.71, lists the number and causes of forest and grassland fires and the acres burned for the past 5 years (2017-2021)**.** For details regarding the location of wildfires, **Appendix A** presents the number of wildfires by County from 2004 to 2021. Additionally, data is presented by County for the likelihood for future occurrence, the total acres burned, and the average annual acreage burned. The Counties with the greatest number of wildfires are Camden, Newton, Washington, Butler, Benton, St. Francois, Jefferson, Henry, Crawford, and Howell. The Counties with the greatest number of acreage burned are Camden, Dallas, Washington, Reynolds, Henry Benton, St. Clair, Laclede, Shannon, and Howell.

Table 3.70 shows the number of fires and acreage burned by forest and grassland fires yearly from 1993 to 2021. Additional information on reporting of wildfires can be found at https://mdc.mo.gov.

Table 3.70. Statewide Forest and Grassland Fires by Cause, 2017-2021

	2017		2018		2019		2020		2021		5 Year Total		5 Year Total	
Cause	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	% of Total Number	% of Total Acreage
Unknown	1664	22128.8	989	13510.9	504	7698.2	702	18551.6	507	9596.6	4366	71486.1	37.3%	40.0%
Debris	1471	16465.3	968	11087.9	429	2723.9	561	4469.0	427	6220.1	3856	40966.2	33.0%	22.9%
Miscellaneous	523	6091.3	308	5955.2	131	1084.7	227	3368.4	207	5024.8	1396	21524.4	11.9%	12.0%
Equipment	221	1123.7	133	1701.0	69	323.3	117	822.0	66	1130.3	606	5100.3	5.2%	2.9%
Arson	185	5310.6	98	8210.3	57	2886.3	75	3226.2	71	7443.0	486	27076.4	4.2%	15.1%
Not Reported	123	2908.4	46	1963.8	27	115.7	40	263.2	35	480.2	271	5731.4	2.3%	3.2%
Smoking	95	1329.3	40	222.8	31	44.5	25	65.5	24	162.3	215	1824.4	1.8%	1.0%
Campfire	60	1110.3	37	136.8	14	30.9	29	290.1	32	518.1	172	2086.3	1.5%	1.2%
Power line	4	10.1	44	343.5	21	527.4	24	235.7	13	56.9	106	1173.6	0.9%	0.7%
Structure	5	4.9	26	192.1	13	54.2	17	11.0	12	8.9	73	271.0	0.6%	0.2%
Lightning	21	150.7	13	796.9	12	11.4	3	2.1	3	2.2	52	963.3	0.4%	0.5%
Fireworks	2	0.0	21	122.1	7	9.7	12	109.5	2	0.0	44	241.3	0.4%	0.1%
Children	18	45.0	3	83.5	2	1.6	5	7.0	3	11.4	31	148.5	0.3%	0.1%
Railroad	8	74.0	5	18.3	2	22.0	3	8.3	4	19.5	22	142.1	0.2%	0.1%
Grand Total	**4400**	**56752.4**	**2731**	**44345.0**	**1319**	**15533.8**	**1840**	**31429.7**	**1406**	**30674.4**	**11696**	**178735.2**	**100.00%**	**100.00%**

Source: Missouri Department of Conservation

Table 3.71. Statewide Forest and Grassland Fires and Acres Burned, 1993–2021

Year	Fires	Acres
1993	2,994	31,952
1994	2,748	51,896
1995	2,910	48,907
1996	3,793	88,933
1997	2,487	29,557
1998	1,112	10,415
1999	1,348	18,270
2000	4,910	132,718
2001	2,972	41,092
2002	2,376	54,397
2003	2,378	47,692
2004	2,917	55,732
2005	1,610	38,921
2006	3,553	52,419
2007	3,058	36,922
2008	2,825	37,534
2009	5,384	88,911
2010	2,798	32,864
2011	4,195	80,925
2012	5,306	89,150
2013	2,381	18,498
2014	5,940	95,797
2015	4,204	38,992
2016	2,811	27,881
2017	4,400	56,752
2018	2,731	44,345
2019	1,319	15,534
2020	1,840	31,430
2021	1,406	30,674
Total	**88,706**	**1,429,110**
Average	**3,059**	**49,280**

Source: Missouri Department of Conservation

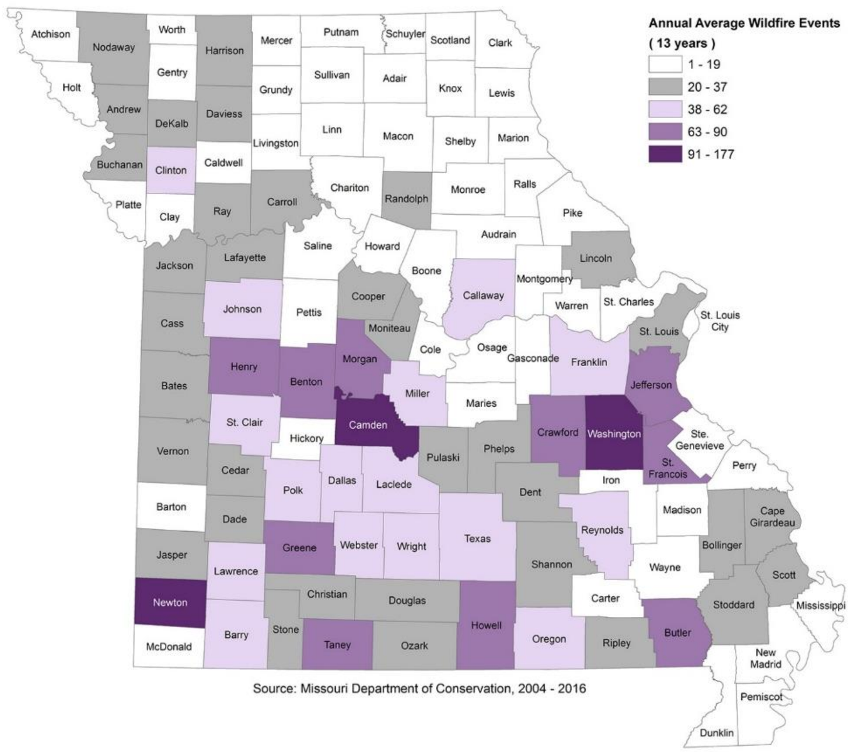
Despite the fact that Missouri experiences an average of 3,059 wildfires each year, Missouri has only received one fire management assistance declaration. This was for the Camden Fire Complex in 2000. At the time of the declaration, the complex consisted of 70 fires burning on 3,000 acres of grassland that had destroyed 17 homes and forced the evacuation of approximately 300 residents in Camden County communities from Macks Creek to Climax Springs.

Probability of Future Hazard Events

As noted, Missouri experiences an average of 3,059 wildfires each year, with most frequent events occurring during spring or late fall, or under conditions of excessive heat, dryness, or drought. However, the likelihood of one of those fires attaining significant size and intensity is unpredictable and highly dependent on environmental conditions and firefighting response. Due to the high percentage of wildfires caused by arson, the occurrence of future wildfire events will strongly depend on patterns of human activity. Events are more likely to occur in wildfire-prone areas experiencing new or additional development. Given the historical frequency of wildfire events and the recommendations of the SRMT, this hazard is determined to have a 100% probability of occurrence within the State.

From the data obtained from the Department of Conservation, the likelihood of occurrence and the annualized acres burned were determined for each county and are presented in **Figure 3.140**

Figure 3.140. Likelihood of Wildfire Events, 2004-2021



Changing Future Conditions Considerations

Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and changing future conditions are also likely to increase the damage from insects and diseases. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover about one-third of the state (See **Figure 3.137**), dominated by oak and hickory trees. As the climate changes, the abundance of pines in Missouri's forests is likely to increase, while the population of hickory trees is likely to decrease.

Higher temperatures will also reduce the number of days prescribed burning can be performed. Reduction of prescribed burning will allow for growth of understory vegetation – providing fuel for destructive wildfires. Drought is also anticipated to increase in frequency and intensity during summer months under projected future scenarios. Drought can lead to dead or dying vegetation and landscaping material close to structures which creates fodder for wildfires within both the urban and rural settings.

Changes are project for location, intensity, frequency, and duration are summarized as follows:

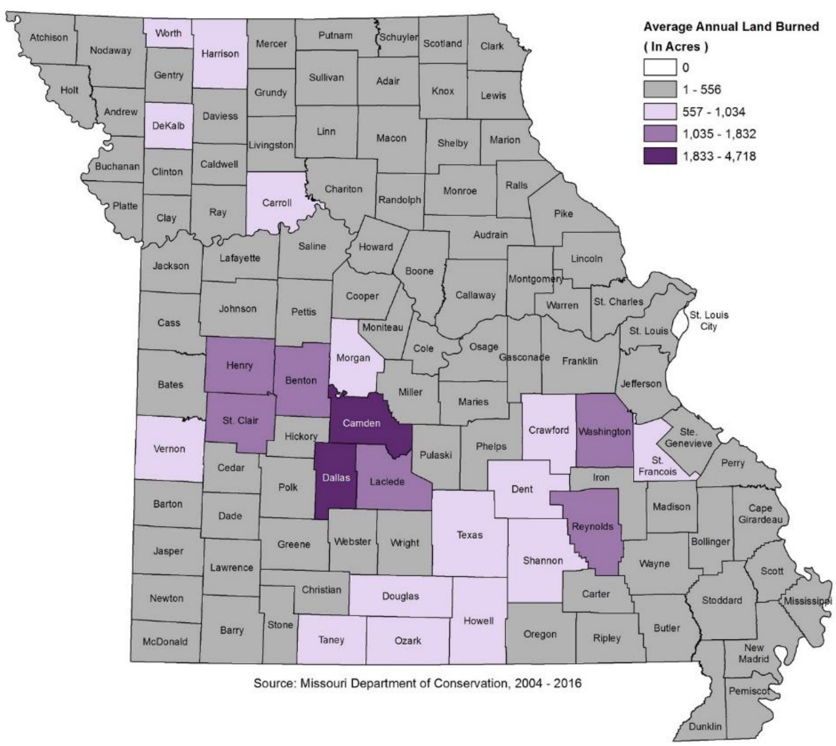
- Location - Climate projections indicate an expansion of the wildfire hazard zone. Warmer, drier conditions also contribute to the spread of the insects that can weaken or kill trees, building up the fuels in a forest.
- Intensity - Climate projections indicate that there could also be an increase in the severity of fire.
- Frequency - Modeled projections of future climate identify a likely increase in the frequency of fire weather occurrence in Missouri and this region of the United States, including an increase in temperature and greater variance in rainfall.

- Duration - The fire season is likely to increase in duration and include a greater number of days with weather that could support fire spread because of longer periods without rain during fire seasons.

State Vulnerability Overview

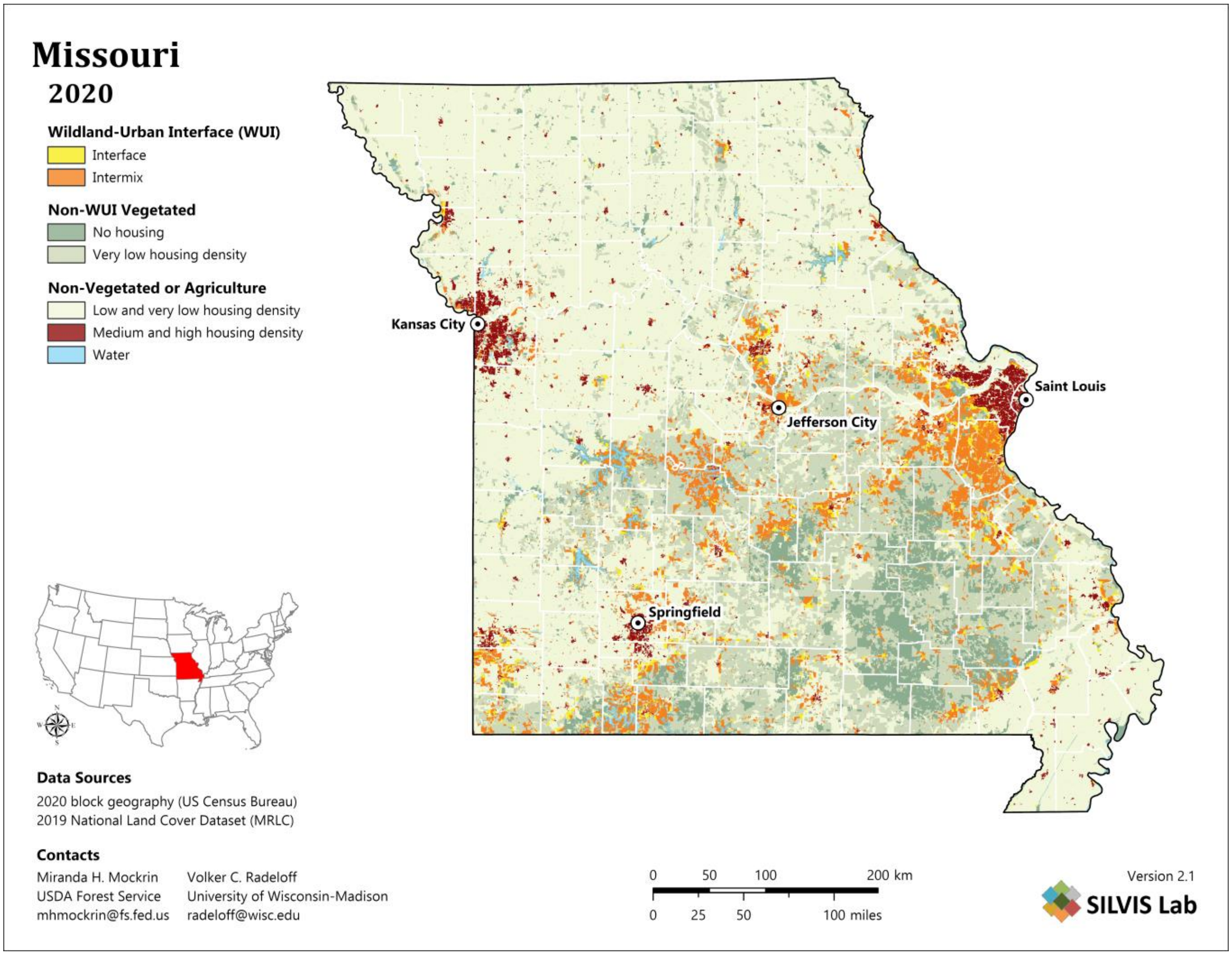
With over 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area. Although the National Fire Incident Reporting System does capture data on wildfires, it was determined that the Department of Conservation historical wildfire data was the best resource. The Department of Conservation data has more individual events recorded per county. Therefore, this data appeared to be more comprehensive. Some fire departments report to both data sets. So, adding the two sets of data together would have double-counted fires. From the Department of Conservation wildfire data from 1993 to 2021, it was determined that the average annual number of wildfires in Missouri was 3,059 burning an average annual 49,280 acres.

Figure 3.141. Average Annual Acreage Burned



The method used to determine vulnerability to wildfires fires across Missouri was a GIS comparative analysis of wildland urban interface and intermix (WUI) areas against building exposure data to determine the types, numbers, and estimated values of buildings at risk to wildfire. This GIS-based analysis utilized data from several sources: the Missouri Spatial Data Inventory Service (MSDIS), LiDAR-derived RiskMAP Footprints, HAZUS building exposure value data, and wildland urban interface and intermix area data from the University of Wisconsin-Madison SILVIS Lab. **Figure 3.142** presents the Wildland Urban Interface (WUI) Areas, 2010.

Figure 3.142. Wildfire Urban Interface (WUI) Areas, 2020



Source: University of Wisconsin -Madison, SILVIS Lab, https://geoserver.silvis.forest.wisc.edu/geodata/wui_change_2020/maps/gifs/white/MO_WUI_v21_white_2020.gif

To calculate estimated values of buildings at risk, buildings values available in the HAZUS census block data were used to determine an average value for each property type. This average value per property type was then applied to the number of structures in the WUI areas, by type, to calculate an overall estimated value of buildings at risk by type. In addition to counts and values of structures at risk, an estimated population impacted for each county was calculated based on the number of residential properties in the WUI areas multiplied by the average household size.

According to this analysis, the following counties have more than 1,000 structures at risk and/or over 1,000 persons at risk to wildfires: Andrew, Buchanan, Crawford, Dent, Grundy, Laclede, Maries, Phelps, and Pulaski. Data for each individual county is presented in **Appendix A**.

Figure 3.143 through **Figure 3.145** provide the results of the wildfire analysis with the numbers and values of various types of structures, and population within the mapped WUI areas.

Figure 3.143. Number of Structures in WUI Interface and Intermix Areas by County

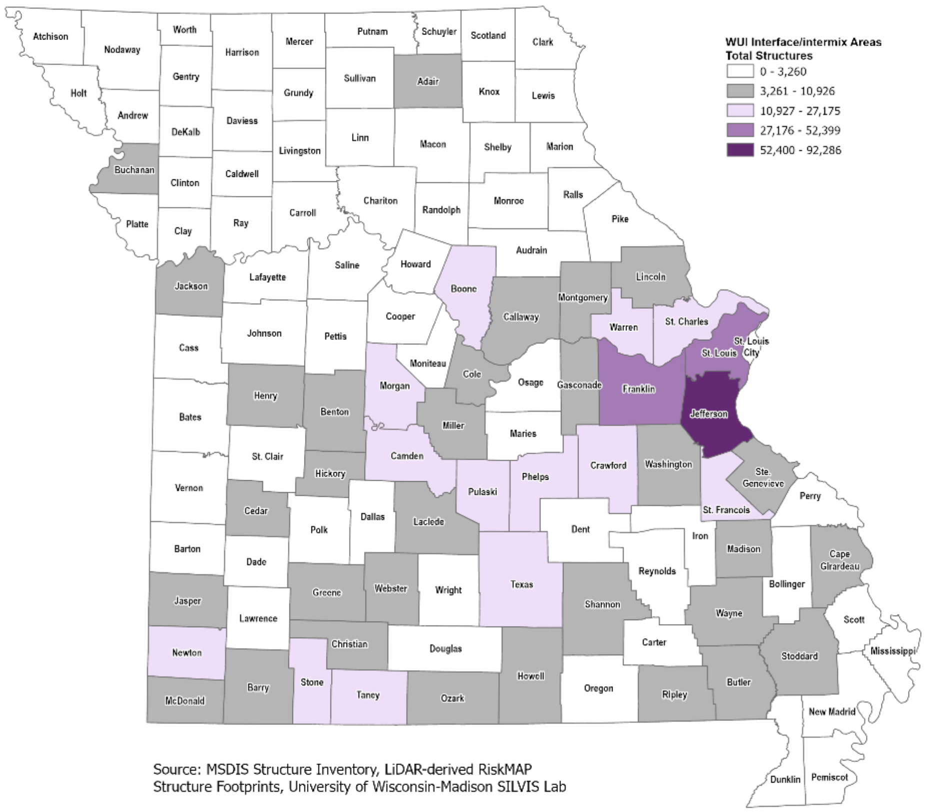


Figure 3.144. Value of Structures in WUI Interface and Intermix Areas by County

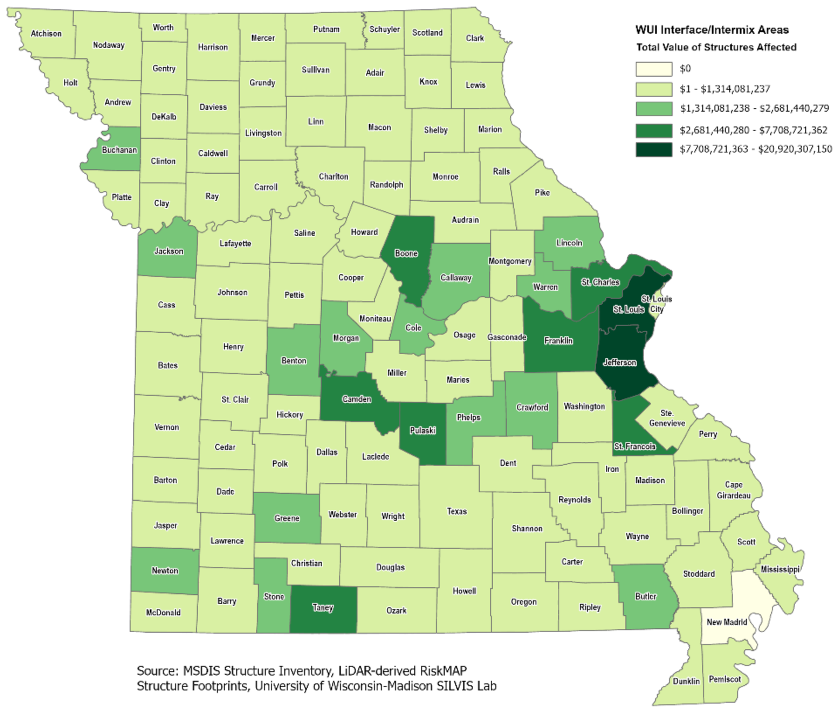
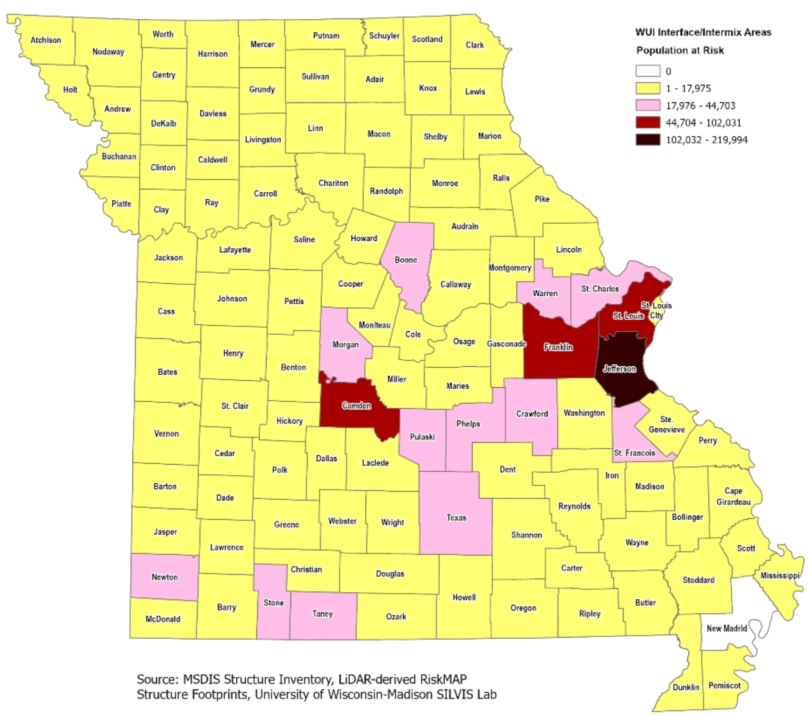


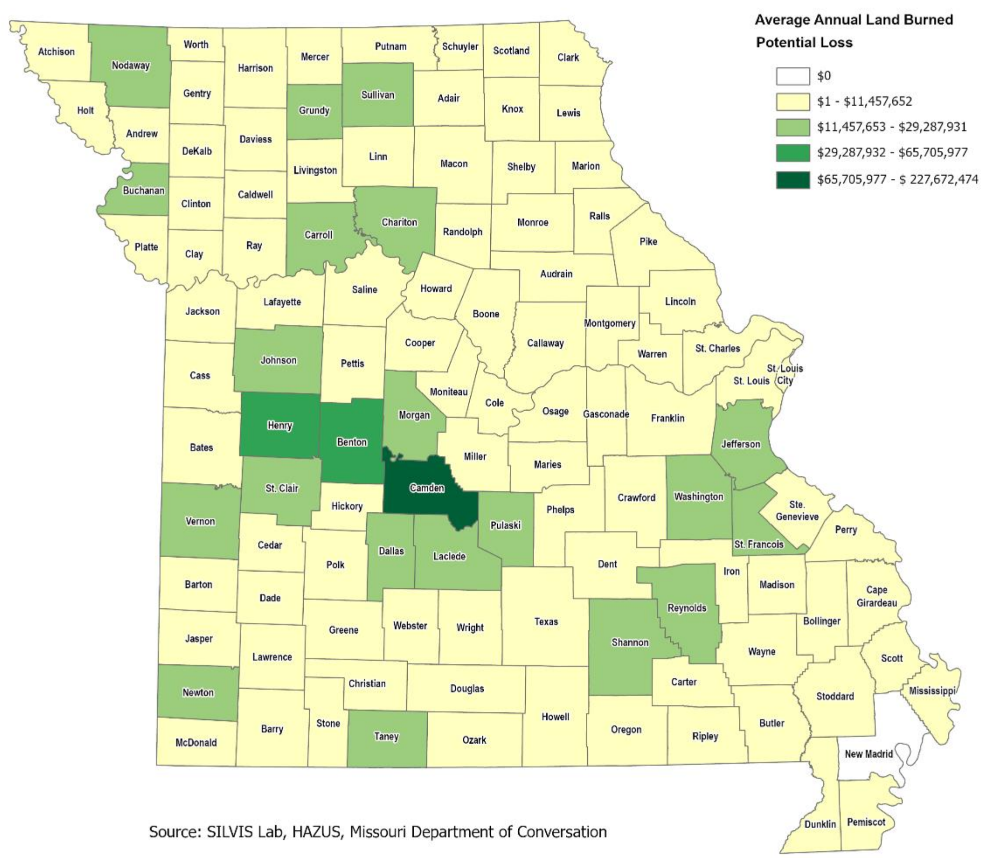
Figure 3.145. Population at Risk to Wildfire in WUI Interface and Intermix Areas



State Estimates of Potential Losses

For the wildfire hazard, the factors considered in determining future potential loss estimates were the average acreage burned each year per county as a result of wildfire and the average value of structures per acre in WU-Interface / Intermix areas. **Appendix A** and **Figure 3.146** that follows provide the potential loss estimates based on this methodology.

Figure 3.146. Wildfire Potential Loss Estimate



Source: SILVIS Lab, HAZUS, Missouri Department of Conversation

An average of 35,747 acres were burned in the 5-year period from 2017-2021 statewide. It is anticipated that associated building damage and potential risk to life of inhabitants will continue.

Hazard Impact on Future Growth and Development

The top 10 counties for annualized loss include Benton, Camden, Chariton, Dallas, Gentry, Harrison, Henry, St. Clair, Taney, and Washington. Of these top 10 counties with structures and population located within the WU-Interface/Intermix areas, Taney is among the top 10 counties for greatest estimated housing unit gains. Housing units within these WUI areas are thus potentially growing and increasing the risk to wildfires.

Risk Summary

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. Wildfires may also be a cascading or secondary impact of another hazard such as earthquakes or tornadoes, as a result of damaged gas lines. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural fires.

Problem Statement:

Using Annualized Wildfire Damage potential loss as a key indicator, the counties most at risk are Laclede, Pulaski, Nodaway, Gentry and Harrison. Mitigation efforts and dollars allocated focused on these counties would most likely be the most beneficial.

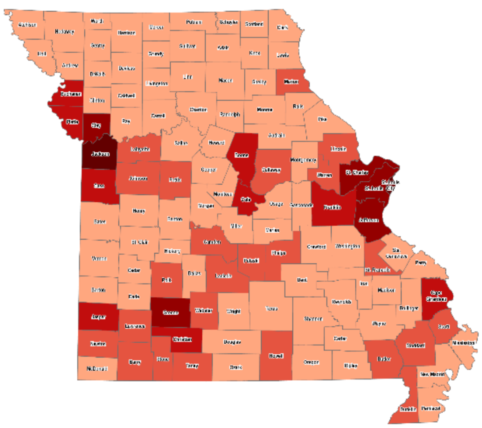
2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.12. Civil Disorder Overview

Description

Civil disorder is a term that generally refers to groups of people purposely choosing not to observe a law, regulation, or rule, usually in order to bring attention to a cause, concern, or agenda. In Missouri, state statutes define civil disorder as "any public disturbance involving acts of violence by assemblages of three or more persons, which cause an immediate danger of or results in damage or injury to the property or person of any other individual."

Vulnerability



Extent/Range of Intensity

The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. The rules of constitutional law set stringent limits on how police officers can behave toward the people they try to arrest. Restraint also plays a crucial part in avoiding any action that "fans the flames." This is particularly important provided that recent protests in Missouri have centered around police brutality. Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. As a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive. Counties particularly vulnerable are, St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin.

Changing Future Conditions Considerations

As a human-caused hazard, any changes in climate would not have a direct impact on civil disorder. Far more relevant, though, could be the implications of future climate change as a cause for civil disorder. Climate change impact forecasts include increasingly extreme weather patterns that exacerbate issues of drought, flooding, severe weather and other weather hazards globally that could affect whole ecosystems. Incidents of civil disobedience could be a secondary result related to societal unrest as a result of other climate-impacted hazards.

Risk Summary/Problem Statement

Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

Description/Location

Civil disorder is a term that generally refers to groups of people purposely choosing not to observe a law, regulation, or rule, usually in order to bring attention to a cause, concern, or agenda. In Missouri, state statutes define civil disorder as “any public disturbance involving acts of violence by assemblages of three or more persons, which cause an immediate danger of or results in damage or injury to the property or person of any other individual.”

Civil disorder can take the form of small gatherings or large groups blocking or impeding access to a building or disrupting normal activities by generating noise and intimidating people. They can range from a peaceful sit-in to a full-scale riot in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. In the 1990s abortion clinics, for example, were targets for these disruptive-type activities.

Throughout this country’s history, incidents that disrupted the public peace have figured prominently. The constitutional guarantees allow for ample expression of protest and dissent, and in many cases collide with the preamble’s requirement of the government “to ensure domestic tranquility.” Typical examples of such conflicting ideology include the protest movements for civil rights in the late 1960s and the Vietnam War protest demonstrations in the early 1970s. The balance between an individual’s and group’s legitimate expression of dissent and the right of the populace to live in domestic tranquility requires the diligent efforts of everyone to avoid such confrontations in the future.

In modern society, laws have evolved that govern the interaction of its members to peacefully resolve conflict. In the United States, a crowd itself is constitutionally protected under “the right of the people to peacefully assemble.” However, assemblies that are not peaceable are not protected, and this is generally the dividing line between crowds and mobs. The laws that deal with disruptive conduct are generally grouped into offenses that disturb the public peace. They range from misdemeanors, such as blocking sidewalks or challenging another to fight, to felonies, such as looting and rioting. Missouri law makes “promoting civil disorder in the first degree” a class C felony, according to Section 574.070 of the Revised Missouri Statutes. As stated in one provision of the law, “Whoever teaches or demonstrates to any other person the use, application, or construction of any firearm, explosive, or incendiary device capable of causing injury or death to any person, knowing or intending that such firearm, explosive or incendiary device be used in furtherance of a civil disorder, is guilty of promoting civil disorder in the first degree.”

Types of Crowds

A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. Crowds can be classified into four general categories:

- **Casual Crowd** — A casual crowd is merely a group of people who happen to be in the same place at the same time. Examples of this type include shoppers and sightseers. The likelihood of violent conduct is all but nonexistent.
- **Cohesive Crowd** — A cohesive crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity, such as worshiping, dancing, or watching a sporting event. Although they may have intense internal discipline (e.g., rooting for a team), they require substantial provocation to arouse to action.
- **Expressive Crowd** — An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of

common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest something.

- **Aggressive Crowd** — An aggressive crowd is made up of individuals who have assembled for a specific purpose. This crowd often has leaders who attempt to arouse the members or motivate them to action. Members are noisy and threatening and will taunt authorities. They tend to be impulsive and highly emotional and require only minimal stimulation to arouse them to violence. Examples of this type of crowd include demonstrations and strikers.

Types of Mobs

A mob can be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, tumultuous, violent, and lawless. Like crowds, mobs have different levels of commitment and can be classified into four categories:

- **Aggressive Mob**—An aggressive mob is one that attacks, riots, and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.
- **Escape Mob**—An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs have lost their capacity to reason and are generally impossible to control. They are characterized by unreasonable terror.
- **Acquisitive Mob**—An acquisitive mob is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property. Examples of acquisitive mobs would include the looting in South Central Los Angeles in 1992, or food riots in other countries.
- **Expressive Mob**—An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent up emotions in highly charged situations. Examples of this type of mob include the June 1994 riots in Canada following the Stanley Cup professional hockey championship, European soccer riots, and those occurring after other sporting events in many countries, including the United States.

Although members of mobs have differing levels of commitment, as a group they are far more committed than members of a crowd. As such, a “mob mentality” sets in, which creates a cohesiveness and sense of purpose that is lacking in crowds. Thus, any strategy that causes individual members to contemplate their personal actions will tend to be more effective than treating an entire mob as a single entity.

Location

Civil disorder can arise from a number of causes for a variety of reasons. Circumstances may be spontaneous, or may result from escalating tensions. Civil disorder can erupt anywhere, but the most likely locations are those areas with large population groupings or gatherings. Sites that are attractive for political or other rallies should be considered as probable locations for the epicenter of civil disorder events; arenas and stadiums are another type of venue where civil disorder can occur. Civil disorder can also occur in proximity to locations where a “trigger event” occurred.

Extent/Range of Intensity

The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property

damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Previous Occurrences

Missouri

Events in Missouri's early history, as well as those from the late 1960s through this decade, indicate the State is not immune to riots, protests, and social upheaval. Some brief examples of Missouri's riotous events are provided below.

In 1906, on the night before Easter Sunday in Springfield, a mob of 6,000, fueled by alcohol, rumors of a woman's rape, and racial tension battered down the jailhouse doors and carried away three men and hanged them in the town square. In the months that followed, a grand jury indicted more than a dozen people for the hangings, and the story of the woman's attack proved to be untrue. In her book about the incident and its aftermath, "Many Thousand Gone," Katherine Lederer notes that until 1906, Springfield had a thriving black population, but the population never recovered after this incident.

On September 22, 1954, a full-scale riot broke out at the Men's State Penitentiary in Jefferson City at about 6:00 p.m., after an inmate released several prisoners. The inmate had obtained keys from a guard by a ruse. At 7:00 p.m., all available state highway patrolmen were directed to report to the penitentiary as quickly as possible to quell the riot. Several buildings and vehicles were burning at that time, and some 500 inmates were loose, hurling bricks, yelling, and attempting to escape. Both chapels were ablaze, as well as several prison shops and factories. Seeing the fires, which were visible at dusk from about 20 miles away, prisoners at the Algoa reformatory and the women's prison staged separate rebellions there. Damage to state property at those facilities was minimal, but at the main prison, only cell houses and buildings equipped with sprinklers survived. By 11:30 p.m., 285 patrolmen in 202 cars were on the scene, and by midnight, some 100 St. Louis policemen carrying submachine guns had arrived by special train. They surrounded cell houses B and C—the only halls in which guards were still held hostage. Highway patrolmen and arriving National Guardsmen took positions on rooftops overlooking the quadrangle—a yard between the larger cell houses. From that vantage point, they opened fire, seriously wounding many inmates in the exchange. Shortly after 7:00 a.m. the next day, the last guard taken hostage was released, and the rioters, having no alternative, gave up shortly thereafter. By mid-morning, 2,000 police officers and National Guardsmen were on duty at the prison. When the riot was over, 3 inmates had been killed and 21 wounded by gunfire. One other prisoner was murdered by stabbing and beating, and eight others were injured in fighting with each other. Five buildings were completely destroyed, and two others partially destroyed, resulting in more than $10 million in losses to state property.

On October 23, 1954, another riot occurred at the State Penitentiary while state troopers were still technically operating the institution. This melee was reportedly fueled by racial tension among inmates and started over food. Bricks began to fly, followed by gunfire from the troopers. Approximately 35 prisoners were wounded in that incident.

On the evening of March 19, 1958, at the Algoa Intermediate Reformatory, east of Jefferson City, quick action by then Governor James T. Blair and a contingent of state highway patrolmen with riot guns quelled a potential inmate uprising. The governor himself and the patrolmen entered the facility amid reports of unrest following the resignation of the institution's acting superintendent. When no trouble occurred, the troopers were removed after about two hours.

On April 9, 1968, the Kansas City Police Department requested the help of the Missouri Highway Patrol in quelling rioting, bombing, and looting in the eastern part of the city in the wake of the assassination of Martin Luther King, Jr. Over 200 officers reported to the staging area at District Four of the State Highway Department to receive their assignments and began patrolling the downtown area. Officers arrested numerous persons for charges ranging from curfew violations to felonious assault. They remained on duty for 10 days until peace was restored.

Twice in May 1969, demonstrations at Lincoln University in Jefferson City resulted in about 200 highway patrolmen being called to the scene to combat arson, sniper fire, and vandalism on campus. The Student Union was burned during those demonstrations.

On February 17, 1975, at Algoa Intermediate Reformatory, a minor riot broke out, resulting in tear gas being thrown into dormitories at the institution. Three prison officials suffered minor injuries, and one inmate required stitches to close a wound. The incident resulted in about $5,000 in property damage.

In December 1977 and January 1978 in Southeast Missouri, farmers making up an American Agricultural Movement staged demonstrations to protest what they felt were unfair prices for their products, as maintained by government price supports. The rallies continued through April 1978 with picketing, tractorcades, and stoppage of highway traffic throughout the area, despite high winds, ice, and snow. More than 300 farm tractors were involved in at least one of these actions. On January 11, highway patrol troopers on Interstate 55 near Hayti arrested seven farmers and charged them with failure to obey a reasonable request, assault, and damaging state property. Four others were arrested on I-55 near Caruthersville for driving their pickup trucks slowly side by side, preventing traffic from passing. Twenty-five farmers with their tractors were involved in a fracas with 12 officers near Hayti. Two patrol cars were damaged, and one officer sustained minor injuries when shoved by an irate farmer into the path of a road grader.

On April 29, 1992, in Warrensburg, racial tensions mounted following the announcement of the controversial Rodney King verdict. The Johnson County Emergency Operations Center was activated for several hours as police remained on alert status for a potential serious disturbance. Military police from nearby Whitman Air Force Base were also placed on standby alert status, but no major problems occurred.

Unrest in Ferguson in August 2014 began when 18 year old Michael Brown was fatally shot by a white Ferguson police officer on August 9th. The disputed circumstances of the shooting sparked existing tensions in the predominately black city, where protests and civil unrest erupted. As the details emerged, a dozen buildings were burned down; there was gunfire, looting, vandalism, and destruction of two St. Louis County Police patrol cars, as well as burning of non-police cars. The events received considerable attention in the US and elsewhere, attracting protesters from outside the region, and raised many questions about relationships between the community and law enforcement, and the militarization of law enforcement. Reporting by local media estimated damages and costs at $5.7 million; the St. Louis County Chief Financial Officer estimated final costs at over $20 million.

In late September 2015, simmering racial tensions reached a breaking point as African-American students at the University of Missouri began to peacefully protest against racist attitudes they saw as prevalent amongst the student body and administration. Specifically, protestors railed against feeling unsafe on campus because of their race, and institutional racism inherent in the university structure. Protests continued through 2015, and resulted in the resignations of the University's President and Chancellor. While no widespread violence or destruction took place during the protests, they did cause major disruption to the operations at the university.

Since 2010, civil unrest has again trended toward race relations as a cause. From controversial shootings of African American men by white police officers to the resulting Black Lives Matter movement, these trends may continue into the future as the country finds ways to improve race relations. As detailed previously in this section, Missouri has experienced specific incidents of racial unrest and violence as part of this trend, and may continue to see these types of incidents in the future.

Specific incidents in a single jurisdiction can cause civil unrest nationally. The Michael Brown shooting incident in Ferguson is an example of this. On November 25, 2014, CNN reported that thousands of people in more than 170 U.S. cities rallied to protest the grand jury decision not to indict the officer involved. Protests also took place internationally, with demonstrations held in several major cities in Canada, and as far away as London. Just six years later, on May 25, 2020 George Floyd is killed by Minneapolis police after being handcuffed and pinned to the ground by Derek Chauvin, a white police officer. A video of the incident is captured and widely shared via social media sparking protests in Minneapolis and around the county. According to the New York Times, protests erupted in at least 140 cities across the United States, and the National Guard was activated in at least 21 states. In St. Louis, a man was killed after protesters blocked Interstate 44, and several others were arrested and injured in the protests that took place days after Mr. Floyds death.

Probability of Future Hazard Events

In their article on "Understanding Riots" published in the *Cato Journal* (Vol. 14, No 1), David D. Haddock and Daniel D. Polsby note that a large crowd itself is not an incipient riot merely because it assembles a great many people. Haddock and Polsby explain that "starting signals" must occur for civil disorder to erupt; these starting signals include certain kinds of high profile events. In fact, incidents can become signals simply because they have been signals in the past. In Detroit, for example, Devils Night (the night before Halloween) has in recent years become a springboard for multiple, independent, and almost simultaneous acts of arson. With any conventional triggering event, such as news of an assassination or unpopular jury verdict, crowds form spontaneously in various places as word of the incident spreads, without any one person having to recruit them. But since not every crowd threatens to evolve into a riot, the authors reason that a significant number of people must expect and desire that the crowd will become riotous. In addition, "someone has to serve as a catalyst—a sort of entrepreneur to get things going." A typical action is the breaking of a window (a signal that can be heard by many who do not necessarily see it). Someone will throw the first stone, so to speak, when he calculates the risk of being apprehended has diminished to an acceptable level. This diminished risk is generally based on two variables—the size of the crowd relative to the police force and the probability that others will follow if someone leads. The authors conclude that once someone has taken a risk to get things started, the rioting will begin and spread until civil authorities muster enough force to make rioters believe they face a realistic prospect of arrest.

Nationwide, riots are apt to be a recurrent, if unpredictable, feature of social life. Without question, Missouri will continue to experience future episodes of marches, protests, demonstrations, and gatherings in various cities and communities that could lead to some type of disruptive civil disorder. However, based on the State's general history of civil disturbance and the various human factors noted above, the probability that such incidents will develop into full-scale, widespread riots is considered low, and noted as <1-percent.

Regarding penal institutions, much has been done in Missouri and other states to alleviate poor living conditions, which are underlying factors in many riots (prison overcrowding, poor treatment of inmates, lack of grievance procedures, etc.). The state has been building new prisons for several years and expanding facilities to create more space and otherwise improve facilities for its inmate population. The number of

individuals on probation and parole as of February 2022 was 62,000. The number of people in one of Missouri's 20 institutions was 23,000. One federal prison, the United States Medical Center for Federal Prisoners, is located in the State, in Springfield. A map of the correctional institutions and probation and parole offices in the State is provided as **Figure 3.147**.

Should Missouri experience future incidents of disruptive civil disorder or rioting, the severity of a given event could range from low to high, depending on many factors. A spirited demonstration that gets out of hand may result in several arrests, minor damage to property (police vehicles with broken windows, etc.), some injuries, and manpower/overtime costs for police, fire, and other response services. To a greater extent, the threat of urban or intercity riots has the potential for millions of dollars in property damage, possible loss of life, and serious injuries, and extensive arrests. Sustaining police at the scene for extended periods, and possibly mobilizing state highway patrol and National Guard units, can add to the extensive manpower costs. Still, such riots tend to be confined to a single site or general area of a community rather than multiple locations or several areas of the State at the same time. Once a riot has occurred, police in other cities are generally on standby for possible riotous conditions and are better able to alleviate potential disturbances before they develop into full-scale riots.

Changing Future Conditions Considerations

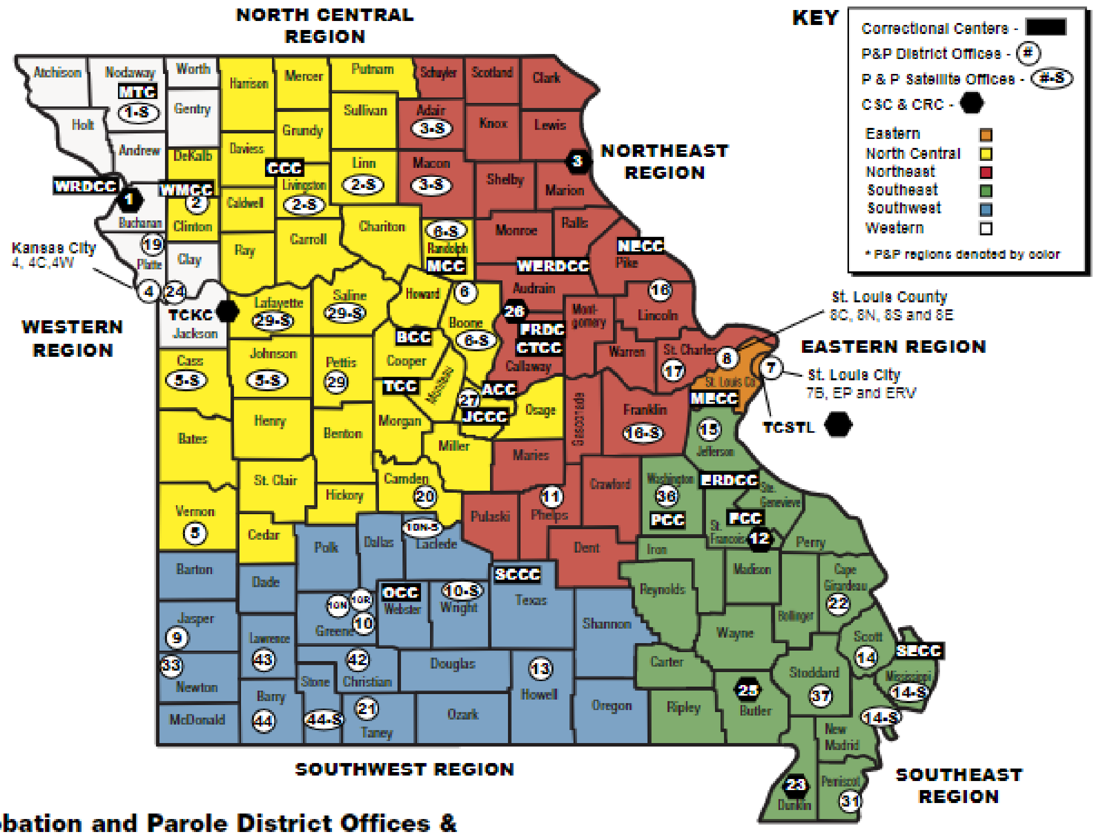
As a human-caused hazard, any changes in climate would not have a direct impact on civil disorder. Far more relevant, though, could be the implications of future climate change as a cause for civil disorder. Climate change impact forecasts include increasingly extreme weather patterns that exacerbate issues of drought, flooding, severe weather and other weather hazards globally that could affect whole ecosystems. Incidents of civil disobedience could be a secondary result related to societal unrest as a result of other climate-impacted hazards.

State Vulnerability Overview

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. The rules of constitutional law set stringent limits on how police officers can behave toward the people they try to arrest. Restraint also plays a crucial part in avoiding any action that "fans the flames." This is particularly important provided that recent protests in Missouri have centered around police brutality. Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. As a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive.

Figure 3.147. Correctional Institutions and Probation and Parole Offices

Correctional Institutions and Probation & Parole Offices



Probation and Parole District Offices & Institutional Parole Offices

1. St. Joseph Community Supervision Center (CSC) (Maryville Satellite), - MTC & WRDCC IPO
2. Cameron (Brookfield and Chillicothe Satellites) - CCC & WMCC IPO
3. Hannibal Community Supervision Center (CSC) (Macon, Kirksville Satellites) - NECC IPO
4. Kansas City (4 offices)
5. Nevada (Belton and Warrensburg Satellites)
6. Columbia (Columbia and Moberly Satellite)
7. St. Louis City (3 offices)
8. St. Louis County (4 offices) 8S-MECC IPO
9. Joplin
10. Springfield (3 offices-Lebanon and Hartville Satellites)
11. Rolla (Steelville Satellite)
12. Farmington Community Supervision Center (CSC)
13. West Plains
14. Sikeston (New Madrid Satellite, Mississippi Satellite) - SECC IPO
15. Hillsboro
16. Troy (Union Satellite)
17. St. Charles
19. Liberty
20. Camdenton
21. Branson
22. Cape Girardeau
23. Kennett Community Supervision Center (CSC)
24. Independence
25. Poplar Bluff Community Supervision Center (CSC)
26. Fulton Community Supervision Center (CSC)
27. Jefferson City -ACC, JCCC & TCC IPO
29. Sedalia (Lexington, Marshall Satellites) - BCC IPO
31. Caruthersville
33. Neosho
36. Potosi
37. Dexter
42. Nixa
43. Aurora
44. Cassville (Galena Satellite)

TCKC: Transition Center of Kansas City (CRC)

TCSTL: Transition Center of St. Louis (CRC)

Correctional Centers

ACC - Algoa Correctional Center, Jefferson City

BCC - Boonville Correctional Center, Boonville

CCC - Chillicothe Correctional Center, Chillicothe

ERDCC - Eastern Reception, Diagnostic & Correctional Center, Bonne Terre

FCC - Farmington Correctional Center, Farmington

FRDC - Fulton Reception & Diagnostic Center, Fulton

CTCC - Cremer Therapeutic Community Center, Fulton

JCCC - Jefferson City Correctional Center, Jefferson City

MTC - Maryville Treatment Center, Maryville

MECC - Missouri Eastern Correctional Center, Pacific

MCC - Moberly Correctional Center, Moberly

NECC - Northeast Correctional Center, Bowling Green

OCC - Ozark Correctional Center, Fordland

PCC - Potosi Correctional Center, Potosi

SCCC - South Central Correctional Center, Licking

SECC - Southeast Correctional Center, Charleston

TCC - Tipton Correctional Center, Tipton

WMCC - Western Missouri Correctional Center, Cameron

WRDCC - Western Reception, Diagnostic & Correctional Center, St. Joseph

WERDCC - Women's Eastern Reception, Diagnostic & Correctional Center, Vandalia

Source: Missouri Department of Corrections Division of Adult Institutions https://doc.mo.gov/media/pdf/printable-map-institution-and-pp-regions

State Estimates of Potential Losses

Providing estimates of potential loss for future incidents of civil disorder is difficult, as good records of damages are not generally consolidated and the parameters of future incidents might be totally different. In order to estimate some level of potential loss, this section uses the recent unrest in Ferguson as an example of baseline impacts. According to the St. Louis CBS affiliate, the unrest of Ferguson cost an estimated $5.7 million. Costs incurred include property damage, police overtime, food and supplies for first responders, and Missouri National Guard activation. More than 80 arrests were made, 13 injuries occurred and as many as 25 buildings were burned and looted. Kansas City reported around $2 million in damages after George Floyd protests in 2020.

Impact of Future Growth and Development on Vulnerability

Prison construction in Missouri, as in many other states, was a growth industry during the 1980s and early 1990s. With the added prison capacity, the number of offenders incarcerated in the Missouri Department of Corrections (DOC) grew form 19,266 in 1995 to 28,567 in 2001. This growth seemed to have no end until a tightening state budget and competing priorities signaled an end to new prison construction. According to several sources, Missouri's prison population has reached an all-time high. The cause of the increase in inmates is unknown, but contributing factors include changes in funding, the economy, and higher crime and conviction rates.

Risk Summary

In the wake of numerous urban riots in the late 1960s and beyond, a unique approach in law enforcement began to emerge as a viable means to reduce the risk of such future riots. Known as "community policing," its philosophy rests on the belief that reducing and controlling serious crime requires the police to pay renewed attention to all problems that allow serious crime to occur. In its comprehensive report following the devastating 1967 Detroit riot for example, the Kerner Commission noted that police "cannot, and should not, resist becoming involved in community service matters."

In his paper entitled "Preventing Civil Disturbances: A Community Policing Approach," Michigan State University professor Robert C. Trojanowicz says community policing can reduce the potential for riots beyond simply reducing racial tensions between the police and the black community. The organizational strategy of community policing, he writes, "requires freeing some police officers from the isolation of the patrol car, so they can work directly in the community and enlist them as partners in the process of policing themselves." Four basic ways community policing can help in riot prevention, the author says, are as follows:

- It provides a means of gathering superior intelligence that allows us to identify areas at risk, the level of threat in those areas, and weaknesses and strengths within the community.
- It provides the police with a way to address those weaknesses, which often include crime, violence, drugs, fear of crime, disorder, neighborhood decay, and juveniles at risk.
- It reaches out to law-abiding people in the community and involves them in the police process, serving as the vital link required to enlist their help in actively promoting order and stability.
- It reduces the overall risk to riots by improving the relations between the police and the black community.

However, the year 2020 was extremely challenging for communities and law enforcement agencies throughout the U.S. High-profile use-of-force incidents led to days of protests; civil unrest; and, tragically,

further violence, destruction, and death. Since then, these protests have, continued to further widen the gap between police agencies and their communities.

Many activists demanding structural changes to law enforcement argue that community policing strategies will not help historically marginalized populations. Derecka Purnell, a human rights lawyer, activist and writer explains that “Community policing is based on this false notion that knowledge keeps people safe, that if the police just knew the people who they were surveilling and harassing, that they could somehow police safer.” Purnell argued that enhanced proximity to law enforcement would instead be detrimental for vulnerable groups and would lead to more frequent interactions that could turn aggressive.

Policing researchers said the inconsistency in how departments use certain community-based policing approaches creates challenges for isolating the outcomes of a particular strategy, and thus determine which approached are more beneficial and just than others. Similarly, the makeup and needs of communities vary, which means the goals and results of community policing tactics will look different. Researchers and activities argue that one important step is for residents to determine what purpose policing should serve in their communities.

Since 2020, during the past two years, what has changed is that the movement to reduce the role, power, and resources of police is steadily gaining ground and building power. The focus is shifting from what is done after harm has already been committed by the police and toward preventing it from happening in the first place.

For example, there have been major advances in reducing the role of armed police. In Brooklyn Center, Minnesota, the American Civil Liberties Union (ACLU) and local allies worked closely with the mayor and city council to pass a law that will create a new department that sends mental health workers instead of police in many situations, start a civilian traffic enforcement department that, and prohibit arrests in many situations that currently result in confrontations escalated by armed police.

Similarly, the ACLU worked alongside allies and city leaders in places like Rochester, New York, and Oakland, California, to move forward on new approaches to public safety, including crisis response teams, restorative justice programs, and assistance for unhoused people — all steps that reduce armed police from traditional enforcement roles. We also saw the evidence grow over the last year that these alternative approaches can save cities millions of dollars and effectively solve needs without the need for any police response at all. The organization also worked with leaders in Rochester, New York, and Oakland, California, to move forward on new approaches to public safety, including crisis response teams, restorative justice programs, and assistance for unhoused people — all steps that reduce armed police from traditional enforcement roles. ACLU also found, over the last year, that these alternative approaches can save cities millions of dollars and effectively solve needs without the need for any police response at all.

Problem Statement:

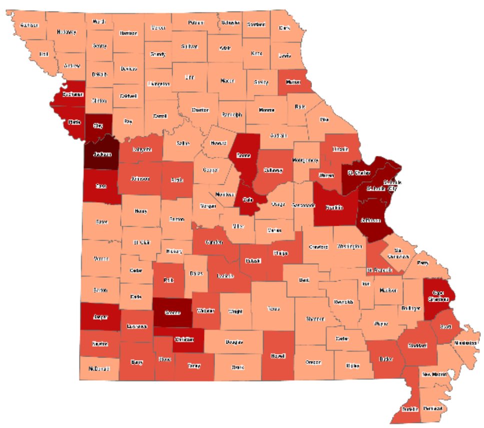
Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties. 2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.13. Cyber Disruption

Description

Cyber disruption is an interruption or disruption of the normal operations, use and/or function of a cybernetic system. Disruptions can typically fall into two very general categories; un-intentional disruption and intentional disruption. Un-intentional disruptions are the more common type of disruption as they usually occur when a portion of the system fails. Intentional disruption is typically a directed 'attack' on a cybernetic system to achieve an intended goal, which is usually malicious in intent.

Vulnerability



Extent/Range of Intensity

The State of Missouri categorizes the severity of a cyber disruption ranging from low to high depending upon the system disrupted and the intention of the attacker. Some systems have redundant capabilities or are not critical to daily operations. As such the severity of a disruption to that system is low. However, there are other systems that are integral to operations, contain sensitive information, or provide access/control to critical systems. A disruption to those systems would have a severe impact on the state.

Probability	Severity	Location
100%	Low to High	Statewide

State Vulnerability Overview

Cyber disruptions have the potential to undermine the confidence that people have in their own security when dealing with any number of cyber systems. Intentional events would also succeed in building doubt in their government's ability to protect them from harm. The potential for a major cyber disruption, through intentional attacks, is the scenario that is more likely to occur, based on currently available information. Attacks of that variety are minimal, though increasing in frequency as the threat evolves. Attackers are likely to have either very specific targets, or desire wide-spread publicity from the attacks that would lead towards the targeting of popular, iconic, or critical systems.

Changing Future Conditions Considerations

Cyber Disruption is considered a human-caused/technological hazard and is not impacted by changes in weather patterns/climate.

Risk Summary/Problem Statement

Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

Description/Location

Cyber disruption is an emerging hazard that has gained increasing notoriety as the vulnerability to disruption grows parallel with the dependence for cybernetic systems. An official definition for cyber disruption has not been solidified amongst professionals and can only be described as an interruption or disruption of the normal operations, use and/or function of a cybernetic system.

Disruptions can typically fall into two very general categories; un-intentional disruption and intentional disruption. Un-intentional disruptions are the more common type of disruption as they usually occur when a portion of the system fails. This can look like a typo or mistake in the code used to design the system or a physical failure of hardware or network. Disruption can also be a cascading effort of a failure of other systems supporting the network, i.e. power.

Intentional disruption is typically a directed 'attack' on a cybernetic system to achieve an intended goal, which is usually malicious in intent. These types of disruptions are the most worrisome to governments as they pose the potential to cause irreparable harm to the function and capability of critical systems or supporting systems that are used in daily operations.

The FBI defines this intentional disruption as a threat: "a cyber-threat is any circumstance or event with the potential to adversely impact operations (including mission, functions, image, or reputation), agency assets, or individuals through an information system via unauthorized access, destruction, disclosure, modification of information, and/or denial of service."

There are many types of cyber disruptions producing a wide variety of societal impacts. Incidents can range from purposeful criminal activities meant to steal money or information, to making public statements (defacto internet protests), to purposefully causing infrastructure damage or injuring persons through disruptions. The most severe cyber-disruption is defined as Cyberterrorism - a terrorist act designed to cause disruptions to computer-based information systems with the express purpose to cause fear, injury or economic loss. In addition to these disruptions, some government entities and businesses are susceptible to cyber activities with some becoming ongoing targets of "hackers" looking to cause harm or promote a personal or political agenda. In many cases, nationally, there are individuals and groups whose mission is to purposefully disrupt and hack systems to cause disruptions and damage.

The most common type of attack cyber criminal's use is the direct denial of service or DDoS attack. This is where a server or website will be pinged rapidly with information requests overloading the system and causing it to crash. DDoS attacks have been a commonly used tool of organizations labeled by the FBI as cyber terrorists such as Anonymous and Lulz Security. Additionally, these organizations have organized website defacements largely as protests perceived injustices and/or groups they consider hate groups.

More sinister attacks have been carried out by other cyber terrorist groups. For example, Russian and Ukrainian hackers attacked a public hospital and stole a more than $1 million from the hospital's payroll system. Additionally, identity theft has been an all-too-common result of cyber-attacks. In 2011 an unknown percentage of Sony's 77 million persons PlayStation Network had their credit card information stolen off the network. According to certain known hacker websites, the list of information was worth hundreds of thousands of dollars to those who stole it.

Though it is an emerging hazard, cyber disruption has not gone unnoticed. The risks associated with the Nation's dependence on these networked technologies led to the development of Presidential Policy

Directive 41 (PPD-41): United States Cyber Incident Coordination, which outlines the roles of federal agencies play during any significant cyber incident, whether involving government or private sector entities.

PPD-41 recognizes that the frequency of cyber incidents is increasing, and this trend is unlikely to be reversed anytime soon. The National Cyber Incident Response Plan (NCIRP) was developed according to the direction of PPD-41). In 2010, the Department of Homeland Security (DHS) issued the NCIRP Interim Version. This plan was recently updated in December of 2016 (https://www.dhs.gov/blog/2016/09/30/national-cyber-incident-response-plan-now-available-public-comment).

In Missouri, the Information Technology Services Division (ITSD), which is part of the Office of Administration (OA), provides direct IT support to nearly all the state government agencies that are under the umbrella of Missouri’s 14 IT-consolidated departments. Within ITSD, the Office of Cyber Security (OCS) is responsible for managing all cyber security related events within the enterprise and ensuring proper administrative and technical controls are implemented to safeguard the State of Missouri’s information system (State of Information Technology in Missouri, 2015, https://oa.mo.gov/information-technology-itsd)

Cyber disruption events can occur and/or impact virtually any location in the State that computing devices are used. A disruption to a cybernetic system can have far-reaching effects beyond the location of the system. As a result, cyber disruption that occurs outside of the state or even the nation can impact Missouri. The converse is true as well; an event that impacts systems in Missouri can cause impacts outside the State.

Extent

The extent or magnitude/severity of a cyber disruption event is variable depending on the nature of the disruption. Impacts of disruption of a small, isolated cybernetic system could impact only a few functions/processes. However, impacts of disruption of large, integrated cybernetic systems could impact many functions/processes, as well as many individuals that rely on those systems.

The State of Missouri categorizes the severity of a cyber disruption ranging from low to high depending upon the system disrupted and the intention of the attacker. Some systems have redundant capabilities or are not critical to daily operations. As such the severity of a disruption to that system is low. However, there are other systems that are integral to operations, contain sensitive information, or provide access/control to critical systems. A disruption to those systems would have a severe impact on the state.

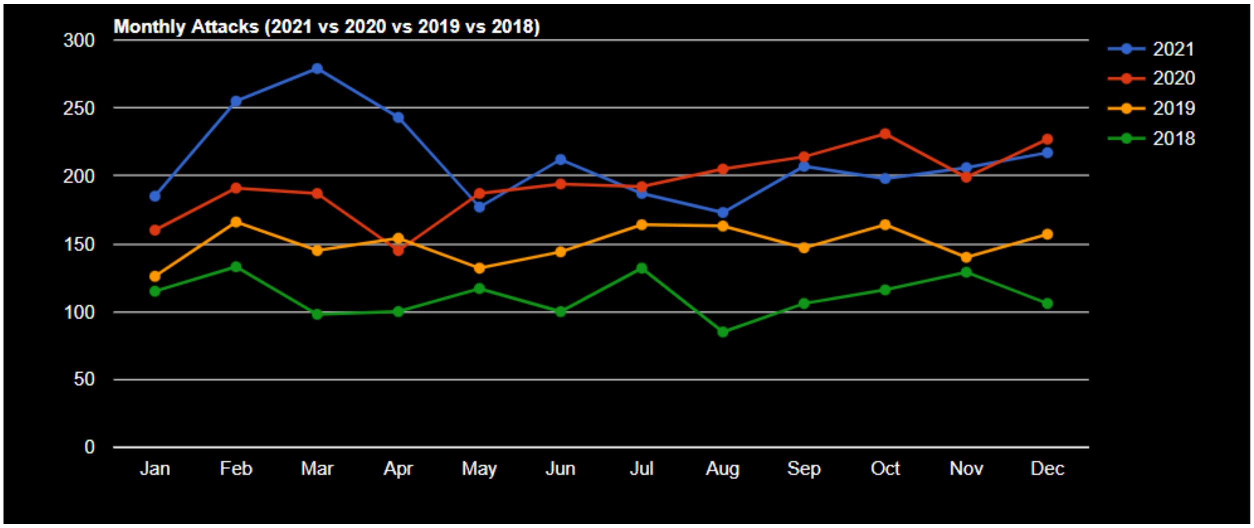
Though a cyber disruption can have limited impacts within a system’s own operations, it also can have extended cascading affects throughout multiple systems. The system that is disrupted and the source of the disruption are major factors in the impact. If it is an intentional disruption and the system is critical then the impact has the potential to quite devastating.

Previous Occurrences

As cyber disruption is an emerging hazard, the reporting and tracking of disruptive events is difficult. In most cases, it is not required to report an event, and when it is reported most of the information is protected due to the sensitive nature of the systems that have been disrupted. However, there currently exist several complex databases that track cyber disruption occurrences. Each system makes use of its own definitions and tracking methods. Hackmageddon is one online source that tracks Cyber Attack Statistics. Hackmageddon was developed by Paolo Passeri, an expert in the computer security industry for more than 15 years and current Principal Sales Engineer at OpenDNS (now part of Cisco). The data for the statistics is derived from timelines that are generally built on a bi-weekly basis. The timelines collect the major cyber

events of the related months chosen among events published by open sources (such as blogs or news sites). It should be noted that this database collects cyberattacks worldwide and this data is provided to show how this hazard is trending in general. During 2021, this database collected reports of a total of 2,539 cyberattacks. The graphic in **Figure 3.148** provides a comparison of the number of attacks collected during 2018 to 2021.

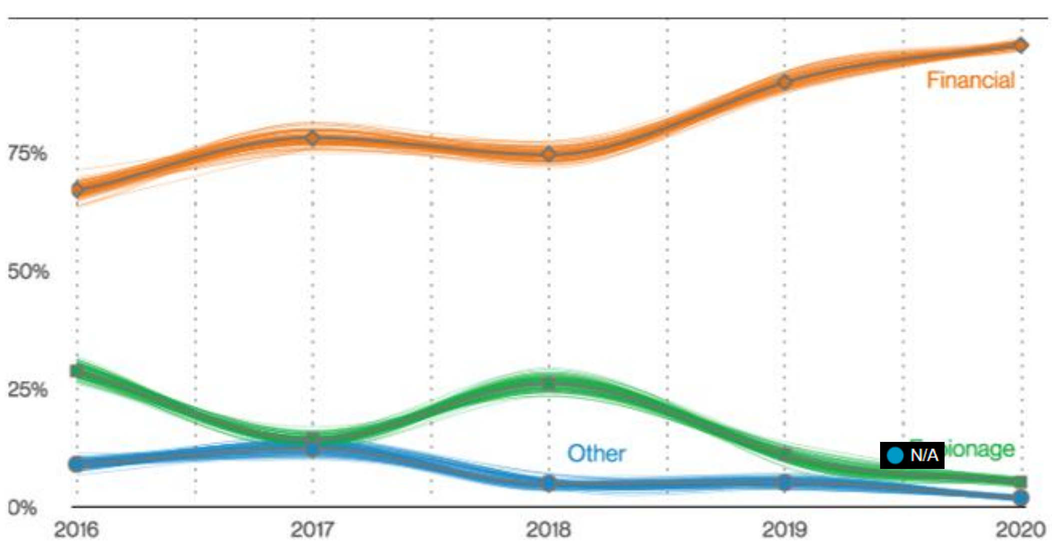
Figure 3.148. Monthly Attacks Collected by Hackmageddon (2018-2021)



Source: Hackmageddon, https://www.hackmageddon.com/2022/01/13/2021-cyber-attacks-statistics/

Figure 3.149 is from the Verizon 2021 Data Breach Investigations Report and shows that 93% of all data breaches had a financial, or espionage motive.

Figure 3.149. Motivations Behind Attacks 2016 – 2020

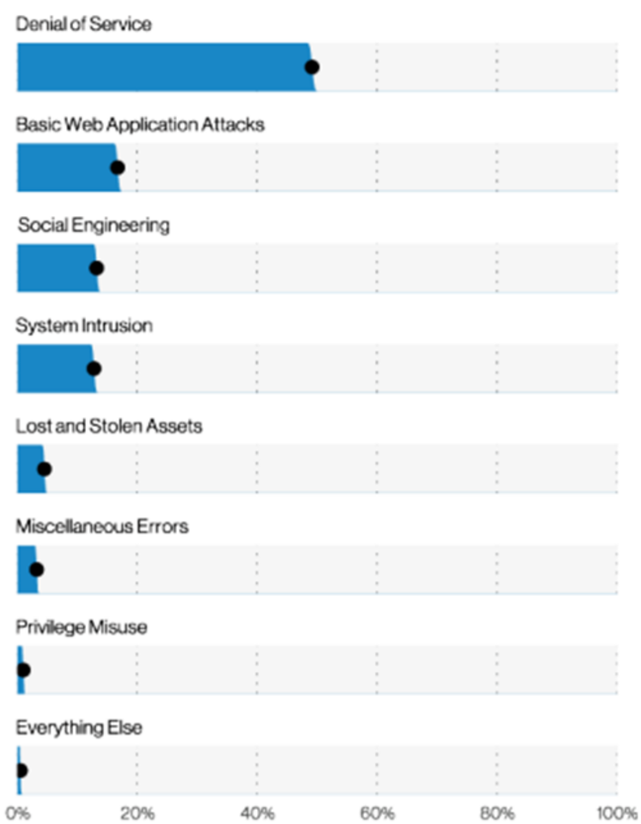


Source: 2021 Verizon Data Breach Investigations Report, https://www.verizon.com/business/resources/reports/2021-data-breach-investigations-report.pdf

There are many types of cyberattack incident patterns, which include:

- Web App Attacks: Incidents in which web applications were attacked, which can include exploiting code-level vulnerabilities in the application.
- Social Engineering: Psychological compromise of a person, which alters their behavior into taking an action or breaching confidentiality.
- System Intrusion: System Intrusion captures the complex attacks that leverage Malware and/or hacking to achieve their objectives including deploying ransomware.
- Insider and Privilege Misuse: Unapproved or malicious use of legitimate privileges.
- Miscellaneous Errors: Incidents in which unintentional actions directly compromise a security attribute of an information asset.
- Lost and Stolen Assets: Incidents where an information asset went missing through misplacement or malice.
- Denial-of-Service Attacks: Any attack intended to compromise the availability of networks and systems that are designed to overwhelm systems, resulting in performance degradation or interruption of service.

Figure 3.150. Cyberattack Incident Percentage (2021)



Source: Source: 2021 Verizon Data Breach Investigations Report, https://www.verizon.com/business/resources/reports/2021-data-breach-investigations-report.pdfx

There have been some notable disruption events that attained national attention in the last few years:

- In May 2021, the Colonial Pipeline Company reported that they were the victim of a cyber security attack that involved ransomware. The attack was orchestrated by DarkSide, a criminal hacker group based in Eastern Europe. The pipeline, which supplies about half of the East Coast's gasoline, went

down for several days, causing gas panic-buying, shortages, and price spikes in some states. (https://www.vox.com/recode/22428774/ransomeware-pipeline-colonial-darkside-gas-prices)

- In April 2021, ransomware gang Revil demanded $50 million from Apple in exchange for data and schematics they claimed to have stolen that were focused on unreleased products. (https://www.wired.com/story/apple-ransomware-attack-quanta-computer/)
- In March 2021, CNA Financial Corp., one of the largest insurance companies in the U.S., paid $40 million to regain access of its network after a ransomware attack. The hackers stole a trove of company data and CAN officials were locked out of their network. (https://www.bloomberg.com/news/articles/2021-05-20/cna-financial-paid-40-million-in-ransom-after-march-cyberattack)
- Between March and December 2020, Russian- based hackers targeted a Texas- based company Solar Winds. The hackers used a routine software update to slip malicious code into the company's software and then used it as a vehicle for a massive cyberattack against America. The attack compromised about 100 companies and about a dozen government agencies. The companies included Microsoft, Intel and Cisco; the list of federal agencies so far includes the Treasury, Justice and Energy departments and the Pentagon. (https://www.npr.org/2021/04/16/985439655/a-worst-nightmare-cyberattack-the-untold-story-of-the-solarwinds-hack)
- June 2016, Voter information. MacKeeper Security Researcher Chris Vickery reported an IP address based out of Serbia had been interacting with an online database holding 154 million U.S. voters' information as early as April 2016 (Chris Vickery, "Another U.S. Voter Database Leak," MacKeeper, June 26, 2016, https://mackeeper.com/blog/post/239-another-us-voter-database-leak).
- February 2016, U.S. Department of Homeland Security, Federal Bureau of Investigation. A hacker with the Twitter handle @DotGovs released online the names and contact information of 29,000 Department of Homeland Security and FBI employees(Lorenzo Franceschi-Bicchierai, "Hacker Publishes Personal Info of 20,000 FBI Agents," Motherboard, February 8, 2016, https://motherboard.vice.com/read/hacker-publishes-personal-info-of-20000-fbi-agents).
- According to Symantec's 2016 Internet security report:
    - In 2015, there were a record-setting total of nine cyber-attacks classified as mega-breaches resulting half a billion personal records stolen or lost. While this number is high, it is considered that many companies do not reveal the full extent of their data breaches.
    - There were over one million web attacks against people each day in 2015 due to an estimated 75 percent of all legitimate websites having unpatched vulnerabilities.
- In 2015, ransomware was developed with the capability to target smart phones, Mac, and Linux systems. Symantec even demonstrated proof-of-concept against smart watches and televisions (https://www.symantec.com/security-center/threat-report).
- Bowman Dam. Iranian hackers reportedly gained control of this New York dam's sluice system in 2013, although the controls were manually disconnected at the time of the cyber breach. In March 2016, the Department of Justice (DOJ) indicted one of the hackers employed at an Iran-based computer company with possible ties to the Islamic Revolutionary Guard Corps (http://www.heritage.org/defense/report/cyber-attacks-us-companies-2016).
- In early January 2013, a series of US bank websites were taken down by denial of service attacks, including Capital One, 5th3rd, and PNC banks (https://www.forbes.com/sites/sap/2013/01/18/cyber-attacks-against-banks-continue-wall-street-we-have-a-problemo-bro/?sh=2223ae3b5627.

- During the 2012 election, requests for absentee ballots in Miami-Dade Florida were discovered to be the first officially documented instance that an election was attempted to be altered by a cyber-attack (http://www.huffingtonpost.com/2013/03/18/florida-cyberattack-election_n_2901969.html).
- In May of 2011, Lockheed Martin was attacked. The attack was detected early and 100,000 accounts were locked as a precaution (http://hackmageddon.com/2012-cyber-attacks-statistics-master-index/)
- July 2015. United Airlines revealed that its computer systems were hacked in May or early June, compromising manifest data that detailed the movements of millions of Americans. The report, citing "several people familiar with the probe," stated that the group behind this attack is the same group suspected of the Office of Personnel Management hack discovered in June. (https://www.csis.org/programs/strategic-technologies-program/significant-cyber-incidents)
- May 2021. On May 6, the Colonial Pipeline, the largest fuel pipeline in the United States, was the target of a ransomware attack. The energy company shut down the pipeline and later paid a $5 million ransom. The attack is attributed to DarkSide, a Russian speaking hacking group. (https://www.csis.org/programs/strategic-technologies-program/significant-cyber-incidents)

According to the 2015 State of Information Technology in Missouri report published by ITSD, during an average month, the state's intrusion prevention system blocks over two million attacks. OCS is responsible for protecting over 60 thousand technology devices and the data that flow through and resides on those devices. The OCS provides around the clock cyber security operations and incident response, cyber security network architecture deployments, identity and access management, and cyber security assessments and auditing. OCS promotes and provides expertise in information security management for all state agencies and supports national and local homeland information security efforts.

Probability of Future Hazard Events

Every second of every day, there will always exist a possibility for both intentional and un-intentional disruptions. To date, historical events within Missouri have tended to be un-intentional. The number of targets for intentional cyber-attacks would seem now to be limited to a couple power plants and government databases. Though they are targets, Missouri is not aware of a current threat against any of the critical facilities or databases. Moving forward, awareness of the growing threat from both domestic and international cyber-attacks does impress the need to develop robust defense and counterattack systems to protect against the increasing likelihood of an attack.

It is difficult to quantify an exact probability or severity of a disruption due to the limited information available and the many unknown factors. The intent of an intentional disruptor could range from something as minor as leaving a message to a major issue with sensitive data collection or control of a critical facility. The probability of an error or failure is also hard to quantify as most systems are properly updated, replaced, and maintained as needed. Usually, it is an extenuating circumstance that drives a failure, which cannot be measured. The probability is thus noted as <1-percent.

Changing Future Conditions Considerations

Cyber Disruption is considered a human-caused/technological hazard and is not impacted by changes in weather patterns/climate.

State Vulnerability Overview

Cyber disruptions have the potential to undermine the confidence that people have in their own security when dealing with any number of cyber systems. Intentional events would also succeed in building doubt in their government's ability to protect them from harm. The potential for a major cyber disruption, through intentional attacks, is the scenario that is more likely to occur, based on currently available information. Attacks of that variety are minimal, though increasing in frequency as the threat evolves. Attackers are likely to have either very specific targets, or desire wide-spread publicity from the attacks that would lead towards the targeting of popular, iconic, or critical systems.

State Estimates of Potential Losses

Due to the variables involved, it is not possible to generate quantitative loss estimates for cyber disruption incidents. The remainder of this section provides a selection of hypothetical scenarios with brief discussions of potential impacts in qualitative terms:

- **Failure of a medical research database:** This would most likely be a localized event that would have minimal losses associated with it if adequate data backup systems are in place. Losses would consist of staff time to restore data from backup as well as down time while the system is inaccessible. Depending on the period of time before the system is brought back on line, associated costs could range from hundreds to thousands of dollars. With this scenario, there are no anticipated injuries or loss of life.
- **Government intranet failure due to hardware failure:** This would also be fairly localized, though external users could also be impacted. Hardware failures are typically able to be replaced within a day or two. Losses would depend on the functionality that is lost while the system is down. Assuming the site is used for general information, inquiries, and some on-line data transactions, the magnitude could be estimated to be in the range of hundreds to thousands of dollars, with no injuries or losses to life.
- **Breach of sensitive database for the justice offices:** This type of event could have broad-reaching effects, depending on if and how the breached data is utilized and whether the public is made aware. Potential losses would be influenced not so much by the event itself, but rather the government's reaction to the event. A partial or complete rebuild of the system and its security processes would occur. In addition, increased security for individuals impacted, as well as resources deployed to identify and prosecute those responsible. A loss of public trust could also entail necessary changes to processes and resources spent to assure the public and re-brand the agency. The magnitude of this type of event could be estimated to be in the range of tens to hundreds of thousands of dollars. Specifically targeted injuries or deaths could result for those whose personal information was revealed.
- **Utility/Infrastructure services remotely accessed and controlled:** This event would be on the scale of a worst-case situation that could have wide-ranging impacts as a result of a coordinated strike on supervisory control and data acquisition (SCADA) industrial control systems impacting utility and infrastructure controls. Targeting of these areas would have the largest health and safety concerns. Losing direct control of any type of utility could have far-reaching impacts to the safety of the public as well as the functionality of any related systems. This domino effect could negatively influence the daily life activities of the public and could take government services completely off-line. Public safety could be put at risk. For example, if electric utility is the target, individuals that rely on power for health-related treatments could be at risk. Prolonged outages would result in loss of automated

traffic control and other power-dependent safety measures. Other utility outages, such as loss of communications would cause additional cascading impacts. This type of event could produce the same impacts as a worse-case natural hazard. The magnitude of losses for this event could reach upwards of millions to billions of dollars. Large scale injuries or deaths could be expected to occur.

Hazard Impact on Future Growth and Development

All areas of the state are considered prone to this hazard. As the populace and infrastructure within Missouri increasingly rely on cyber systems in daily operations, the risk for cyber disruption will only increase. This is a newly developing threat so as more resources are devoted to countering the hazard; the risk to a disruption would hopefully decrease. As infrastructure and facilities are upgrade while new development occurs, planners will need to keep in mind the potential for disruption to essential services due to cyber disruption.

Risk Summary

Cyber Disruption is an emerging hazard that has gained an increasing notoriety as the vulnerability to disruption grows parallel with the dependence for cybernetic systems. Due to the variables involved in the type of disruption (un-intentional vs. intentional), motives of intentional attacks, methods of intentional attacks, and targets of intentional attacks, it is not possible to predict when, how, or where cyber disruption can occur. Mitigation opportunities for this hazard include continued diligence of the States ITSD OCS as well as other government and private-sector entities to continue to monitor, block, and report cyber-attacks as well as continually assess the vulnerability of systems to intentional or unintentional disruptions. Private citizens must also maintain an awareness of potential threats and vulnerabilities to protect private systems.

Problem Statement:

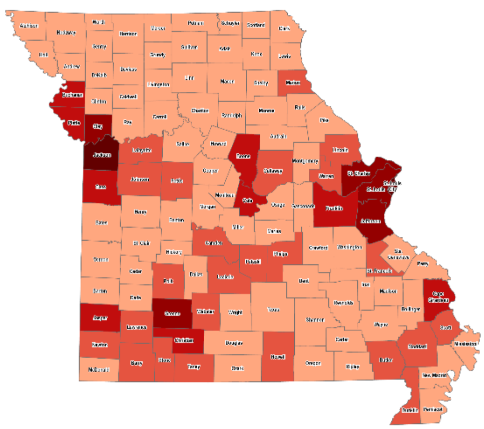
Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties. 2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer:

https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.14. Environmental Health Emergencies

Description

Environmental health is a branch of public health that focuses on the relationships between people and their environment. Environmental health is a key part of any comprehensive public health system. It focuses on topics that include chemical and other environmental exposures in air, water, soil, and food, and the impacts that various pollutants have on the environment and thus the health of people and communities. Environmental health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident.

Vulnerability	Extent/Range of Intensity
	Two scales for measuring the intensity of an environmental health emergency are the US Air Quality Index and Missouri's Water Quality Standards. The U.S. Air Quality Index (AQI) is the EPA's index for reporting air quality. Missouri's Water Quality Standards (WQS) are defined in the Code of State Regulations (10 CSR 20-7.031). The objective of WQS is protecting uses through applying criteria. Water quality criteria are expressed as concentrations, loads or narrative statements.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Environmental incidents involving air and water pollution would likely impact a more localized area; however, long-term effects on the environment in the impacted area could linger for many years. Although Missouri has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people.

Changing Future Conditions Considerations

Higher temperatures lead to an increase in allergens and harmful air pollutants. For instance, longer warm seasons can mean longer pollen seasons – which can increase allergic sensitizations and asthma episodes and diminish productive work and school days. The frequency of heavy precipitation events has already increased for the nation as a whole and is projected to increase in all U.S. regions. In addition to the immediate health hazards associated with extreme precipitation events when flooding occurs, other hazards can often appear once a storm has passed.

Risk Summary/Problem Statement

Using population and major transportation corridors as key indicators, the data suggests that counties at most risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

Description/Location

Environmental health is a branch of public health that focuses on the relationships between people and their environment. Environmental health is a key part of any comprehensive public health system. It focuses on topics that include chemical and other environmental exposures in air, water, soil, and food, and the impacts that various pollutants have on the environment and thus the health of people and communities.

Environmental health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. For more information on those particular incidents, see **Sections 3.3.10** (Tornadoes), **3.3.1** (Riverine Flooding), and **3.3.15** (Hazardous Materials). The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Environmental health emergencies tend to be more localized in scope, however, depending on the magnitude of an incident or how diffusive the medium is, they can have regional or large-scale impacts.

An emerging issue of great concern, with far reaching consequences is the release of a radiological, chemical, or biological agent, as a terrorist act of sabotage to adversely impact a large number of people. For more information on biochemical terrorism, see **Section 3.3.20**. Additional environmental health concerns addressed in this hazard profile focus on air and water pollution, because contamination of those media can have widespread impacts on public health and devastating consequences. Particular issues of primary concern associated with sources of air and water pollution change over time depending on recent industrial activity, economic development, enforcement of environmental regulations, new scientific information on adverse health effects of particular contaminants or concentrations, and other factors.

Research has shown that people who live, work, and play in the most polluted environments in the U.S. are primarily communities of color and low-income communities. The Toxic Release Inventory (TRI) was created in 1986 under the Emergency Planning and Community Right-to-Know Act to support emergency planning and publicize information about toxic releases. On average, people of color make up 56% of the population living in neighborhoods with TRI facilities, compared to 30% elsewhere. Negative environmental factors can compound social and economic conditions and lead to higher levels of chronic health problems such as asthma, diabetes, and hypertension for minorities and low-income communities.

Known as Environmental Justice, the EPA and other federal agencies work to improve and maintain a clean and healthful environment for those who have traditionally been burdened with high rates of pollution exposure. Signed in 1994, Executive Order 12898 directed federal agencies to develop environmental justice strategies to help address disproportionately high and adverse human health or environmental effects of their programs on minority and low-income populations. The use of pollution standards, permitting, licensing, and strict regulations all help to achieve environments where all people enjoy the same degree of protection from environmental and health hazards.

Air Pollution

Air quality is defined in terms of both ambient air (outdoor air) and indoor air. According to the Environmental Protection Agency (EPA), ambient air refers to the atmosphere that is external to buildings where the general public has access.

Exposure to air pollution can affect everyone's health. No matter where you live, you can be exposed to air pollution. The type and amount of exposure varies depending on your location, the time of day, and even the weather. Exposure to air pollution is higher near pollution sources like busy roadways or wood-burning equipment. Many of our daily activities expose us to higher levels of air pollution. Idling cars, gas-fueled equipment and chemicals we use in our homes all contribute to overall air pollution and expose us to harmful air pollutants. On any given day, the types and amounts of pollution we breathe vary by our location, the time of day and even the weather.

Under the Clean Air Act (CAA), the EPA sets limits on certain air pollutants, including how much can be in the air anywhere in the United States. The CCA also give the EPA the authority to limit emissions of air pollutants coming from sources like chemical plants, utilities, and steel mills. Individual states or tribes may have stronger air pollution laws, but they may not have weaker pollution limits than those set by EPA.

The EPA sets national air quality standards for six common pollutants, also called criteria pollutants, to protect public health. These pollutants are found all over the U.S. and harm people's health and the environment, and even cause property damage. The six pollutants are: Ozone (O3), Particulate matter (PM10 and PM2.5), Carbon monoxide (CO), Nitrogen dioxide (NO2), Sulfur dioxide (SO2), and Lead (Pb). PM10 includes particles less than or equal to 10 micrometers in diameter and PM2.5 includes particles less than or equal to 2.5 micrometers and is also called fine particle pollution.

Ozone

Tropospheric, or ground level ozone, is not emitted directly into the air, but is created when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources chemically react in the presence of sunlight.

Ozone is an irritant that damages lung tissue and aggravates respiratory disease. It can be particularly harmful on hot-sunny days in urban environments, when ozone can reach unhealthy levels. It can also be transported long distances by wind, so even rural areas can experience high ozone levels.

Ozone can trigger a variety of health problems. Those most susceptible to ozone include children, the elderly and individuals with pre-existing respiratory problems, like asthma. Children are at increased risk from exposure to ground-level ozone because their lungs are still developing. Healthy adults can experience problems breathing, especially those who exercise or work outdoors when ozone levels are high.

Particulate Matter

Particulate matter (PM), or particle pollution, is a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.

- **PM10:** inhalable particles, with diameters that are generally 10 micrometers and smaller
- **PM2.5:** fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller

Some PM are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires, and others form in the atmosphere as a result of complex reactions of chemicals which are pollutants emitted from power plants, industries, and automobiles. PM10 can get deep into your lungs, and some may even get into your bloodstream. PM2.5 pose the greatest risk to health.

Carbon Monoxide

Carbon Monoxide (CO) is a colorless, odorless gas that can be harmful when inhaled in large amounts and released when something is burned. The greatest sources of outdoor CO are cars, trucks and other vehicles or machinery that burn fossil fuels.

Breathing air with a high concentration of carbon monoxide, CO, reduces the amount of oxygen that can be transported in the blood stream to critical organs like the heart and brain. At very high levels, which are possible indoors or in other enclosed environments, CO can cause dizziness, confusion, unconsciousness and death. Very high levels of CO are not likely to occur outdoors. However, when CO levels are elevated outdoors, they can be of particular concern for people with some types of heart disease. These people already have a reduced ability for getting oxygenated blood to their hearts in situations where the heart needs more oxygen than usual. They are especially vulnerable to the effects of CO when exercising or under increased stress. In these situations, short-term exposure to elevated CO may result in reduced oxygen to the heart accompanied by chest pain also known as angina.

Nitrogen Dioxide

Nitrogen dioxide primarily gets in the air from the burning of fuel and forms from emissions from cars, trucks and buses, power plants, and off-road equipment. Breathing air with a high concentration of nitrogen dioxide can irritate airways in the human respiratory system. Such exposures over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing).

Longer exposures to elevated concentrations of NO2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. People with asthma, as well as children and the elderly are generally at greater risk for the health effects of nitrogen dioxide.

Sulfur Dioxide

The largest source of sulfur dioxide in the atmosphere is the burning of fossil fuels by power plants and other industrial facilities. Smaller sources of sulfur dioxide emissions include industrial processes such as extracting metal from ore; natural sources such as volcanoes; and locomotives, ships and other vehicles and heavy equipment that burn fuel with a high sulfur content.

Short-term exposures to sulfur dioxide can harm the human respiratory system and make breathing difficult. People with asthma, particularly children, are sensitive to these effects. Sulfur dioxide emissions that lead to high concentrations in the air generally also lead to the formation of other sulfur oxides. Sulfur oxides can become small particulate matter that can penetrate deeply into the lungs and in sufficient quantity can contribute to health problems.

Lead

Sources of lead emissions vary from one area to another. At the national level, major sources of lead in the air are ore and metals processing and piston-engine aircraft operating on leaded aviation fuel. Other sources are waste incinerators, utilities, and lead-acid battery manufacturers. The highest air concentrations of lead are usually found near lead smelters.

Once taken into the body, lead distributes throughout the body in the blood and is accumulated in the bones. Depending on the level of exposure, lead can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. The effects most likely to be encountered in current populations are neurological effects in children. Infants and young children are especially sensitive to lead exposures, which may contribute to behavioral problems, learning deficits and lowered IQ.

Hazardous Air Pollutants

Hazardous air pollutants (HAPs) (also called toxic air pollutants or air toxics) are pollutants that are known or suspected to cause serious health problems such as cancer. There are 188 hazardous air pollutants. Examples of toxic air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper. Examples of other listed air toxics include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds.

In Missouri, the Air Pollution Control Program strives to maintain and improve the quality of Missouri's air to protect public health, general welfare and the environment. This program reports to the Missouri Air Conservation Commission and the Division of Environmental Quality and is responsible for upholding CAA requirements and carrying out the Missouri Air Conservation Law which sets specific air quality standards for the state. The Air Pollution Control Program also provides air permits which limit the amount of air pollution allowed from a "stationary source." These permits follow both federal and state laws.

Due to high amounts of ozone, carbon dioxide, nitrogen compounds, and other vehicular pollutants in the St. Louis metropolitan area, vehicles registered in the City of St. Louis, Franklin County, Jefferson County, St. Charles County, and St. Louis County are required to have their exhaust systems routinely checked to determine whether emissions standards are being achieved. In addition, all service stations around St. Louis are now required to have new gas nozzles that recapture gasoline vapors, thus preventing them from being released to the atmosphere. These vapors (unburned hydrocarbons) chemically react with nitrogen oxides when exposed to the sunlight and form ozone, which is the basis for smog. For more information on Missouri's Air Pollution Control Program, contact the Missouri Department of Natural Resources at https://dnr.mo.gov/about-us/contact.

Water Pollution

When the water in rivers, lakes, and oceans becomes polluted, it can endanger wildlife, make drinking water unsafe, and threaten the waters where people swim and fish. Water is uniquely vulnerable to pollution as it is known as a "universal solvent," water is able to dissolve more substances than any other liquid on earth. As a result, water is so easily polluted – toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution. All of the hydrologic systems are connected so protecting Missouri's water quality, means monitoring drinking water, lakes, streams and rivers, wastewater and stormwater. While Missouri Department of Natural Resources monitors and researches several substances and pollutants, many of them do not cause widespread problems, in part because many of the Country and State's rules and requirements have led to adequate controls.

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under the CWA, the EPA has

implemented pollution control programs such as setting wastewater standards for industry. The EPA also developed national water quality criteria recommendations for pollutants in surface waters.

The term pollutant is defined very broadly in the Clean Water Act. It includes any type of industrial, municipal, and agricultural waste discharged into water. Some examples are dredged soil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste.

The EPA also sets legal limits on over 90 contaminants in drinking water. The legal limit for a contaminant reflects the level that protects human health and that water systems can achieve using the best available technology. EPA rules also set water-testing schedules and methods that water systems must follow.

The Safe Drinking Water Act (SDWA) gives individual states the opportunity to set and enforce their own drinking water standards if the standards are at a minimum as stringent as EPA's national standards. The rules for drinking water can be grouped by two contaminant types, chemical contaminants and microbial contaminants.

Point Source Pollution

The CWA made it unlawful to discharge any pollutant from a point source into navigable waters unless a permit is obtained. Authorized by the CWA, the EPA maintains the National Pollutant Discharge Elimination System (NPDES). The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discreet, defined, or discernible conveyances such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container. Point sources also include vessels or other floating craft from which pollutants are or may be discharged. By law, the term "point source" also includes concentrated animal feeding operations, which are places where animals are confined and fed.

To view NPDES storm water outfalls, animal feeding operations, and wastewater outfalls, visit the Missouri Department of Natural Resources GIS website (https://gis-modnr.opendata.arcgis.com/).

Nonpoint Source Pollution

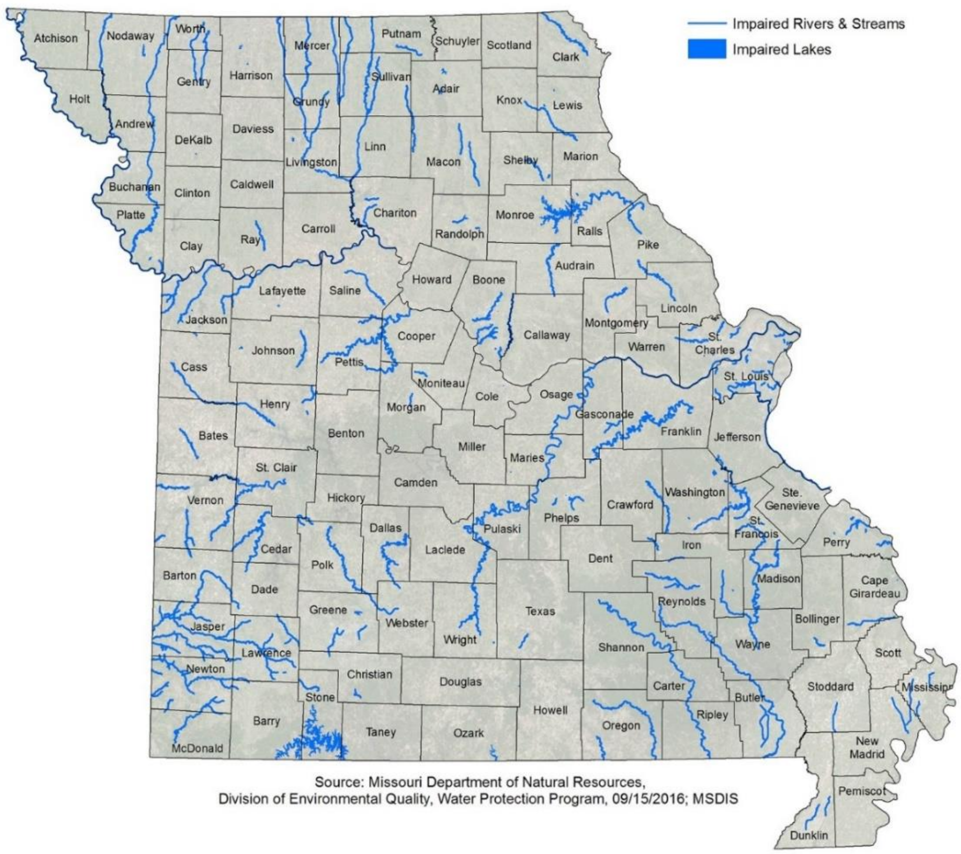
Nonpoint source pollution (NPS) happens when water from rainfall, snowmelt or irrigation runs over land or through the ground and picks up pollutants and deposits them into rivers, streams, lakes, wetlands, or groundwater. NPS pollution has significant impacts on water quality in Missouri. Pollution from nonpoint sources – storm sewers, failing septic systems, and underground storage tanks, and runoff from construction sites, mining areas, crop fields, pastures and confined animal feeding operations, and paved surfaces, rooftops and lawns — contribute huge quantities of bacteria, sediment, nitrate and phosphorus, chloride and other pollutants to Missouri’s surface waters and groundwater. Nonpoint source pollution is the greatest threat to the state’s waters. NPS was responsible for 87% of rivers and streams and 59% of lakes on Missouri’s 2020.

Missouri department of Natural Resources takes two general approaches to managing NPS pollution, one that relies on voluntary action through the Nonpoint Source Management Program which offers monetary incentives and grants, and the second approach is regulation focused. While most nonpoint sources of pollution are not formally regulated, there are some activities that require a permit from the

department. Permits are issued to control stormwater runoff from land disturbance activities of an acre or more, as well as for certain industries like biodiesel manufacturers, agrichemical producers and Concentrated Animal Feeding Operations (CAFOs).

There are currently 115,701 miles of classified streams in Missouri and 136,236 miles of unclassified streams. There are 321,736 acres of classified lakes and 382,429 acres of unclassified lakes. **Figure 3.151** presents the streams and lakes deemed impaired due to contamination.

Figure 3.151. Streams and Lakes Deemed Impaired by the 2016 Missouri Water Quality Report



Source: Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program, 09/15/2016; MSDIS

Bacteria and Pathogens

Bacteria are natural and can be found in land, water, as well as in and on humans and animals. But some are harmful and, if ingested by humans, can cause sickness or even death. Bacteria in streams and lakes can be harmful when the source comes from a human or animal. Problematic sources of bacteria often come from failing septic systems, wastewater treatment plant releases, livestock, urban stormwater, pets, and wildlife. In addition to bacteria, human and animal waste may contain pathogens such as viruses and protozoa that could be harmful to humans and other animals.

Cyanobacteria

Algal blooms caused by cyanobacteria, also known as blue-green algae, are harmful because they may produce toxins that can make people and animals sick if they come into contact with the polluted water, consume tainted fish or shellfish, or drink contaminated water.

Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Sources of nutrients include wastewater and run-off from farm fields and lawns. Harmful algal blooms typically take place during summer and early fall when the weather is warm and water temperatures are high. Blooms can be found throughout Missouri. Lakes and ponds are the most likely waterbodies to experience blooms, but they also can occur in streams, especially if they are slow moving or pooled.

Skin irritation or rash is the most commonly reported health effect. Other symptoms range from diarrhea, cramps and vomiting, to fainting, numbness, dizziness, tingling and temporary paralysis. The most severe reactions occur when large amounts of water are swallowed. Inhalation of aerosolized toxins may result in allergy or asthma-like symptoms.

Mercury

Mercury is a naturally occurring metal found primarily in a mineral called cinnabar. Mercury is released through the natural weathering of rock and volcanic activity, however, the main source of mercury in the environment is from human activity through coal-combustion electrical power generation and industrial waste disposal. Once mercury is released to the environment, it can be converted to a biologically toxic form of methylmercury by microorganisms found in soil and in the aquatic environment.

Mercury is extremely poisonous, and we can absorb it by touch, inhalation, or consumption. Mercury is a concern because it is absorbed easily into the food chain, particularly fish. It builds up in the body with each exposure and is very difficult to remove. Over exposure can cause mercury poisoning which is unpleasant and potentially fatal.

Extent/Range of Intensity

The U.S. Air Quality Index (AQI) is the EPA's index for reporting air quality. The AQI is used for five major air pollutants regulated by the Clean Air Act: ozone, PM2.5 and PM10, carbon monoxide, sulfur dioxide, and nitrogen dioxide. The index uses values from 0 to 500 – the high the value the greater the level of air pollution and the greater the health concern. AQI values at or below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is unhealthy, particularly for certain sensitive groups of people, and progressively worse for everyone as AQI values get higher. The AQI is divided into six categories. Each category corresponds to a different level of health concern. Each category also has a specific color. The figure on the following page shows the different AQI levels and corresponding information. Missouri operates a network of about 50 ambient air monitoring sites and provides current AQI data here: https://dnr.mo.gov/air/hows-air/current-air-quality.

Figure 3.152. Air Quality Index

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Source: AirNow: https://www.airnow.gov/aqi/aqi-basics/

Missouri's Water Quality Standards (WQS) are defined in the Code of State Regulations (10 CSR 20-7.031). The objective of WQS is protecting uses through applying criteria. Water quality criteria are expressed as concentrations, loads or narrative statements. The level of protection given to a stream, river or lake depends on the expected, or "designated use(s)," of that water. Once assigned a designated use, a water body is considered "classified" and listed in Missouri's WQS as such. Residents can search for classification and designated uses of any body of water in the state using the department's Water Quality Standards Map Viewer:
https://modnr.maps.arcgis.com/apps/webappviewer/index.html?id=1d81212e0854478ca0dae87c33c8c5ce.

A Total Maximum Daily Load (TMDL) is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for a particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant. According to the Clean Water Act, each state must develop TMDLs for all the waters identified on their Section 303(d) list of impaired waters, according to their priority ranking on that list. TMLD analysis and designations are based on a variety of factors including the waterbody type, complexity of flow conditions and pollutant causing the impairment.

Previous Occurrences

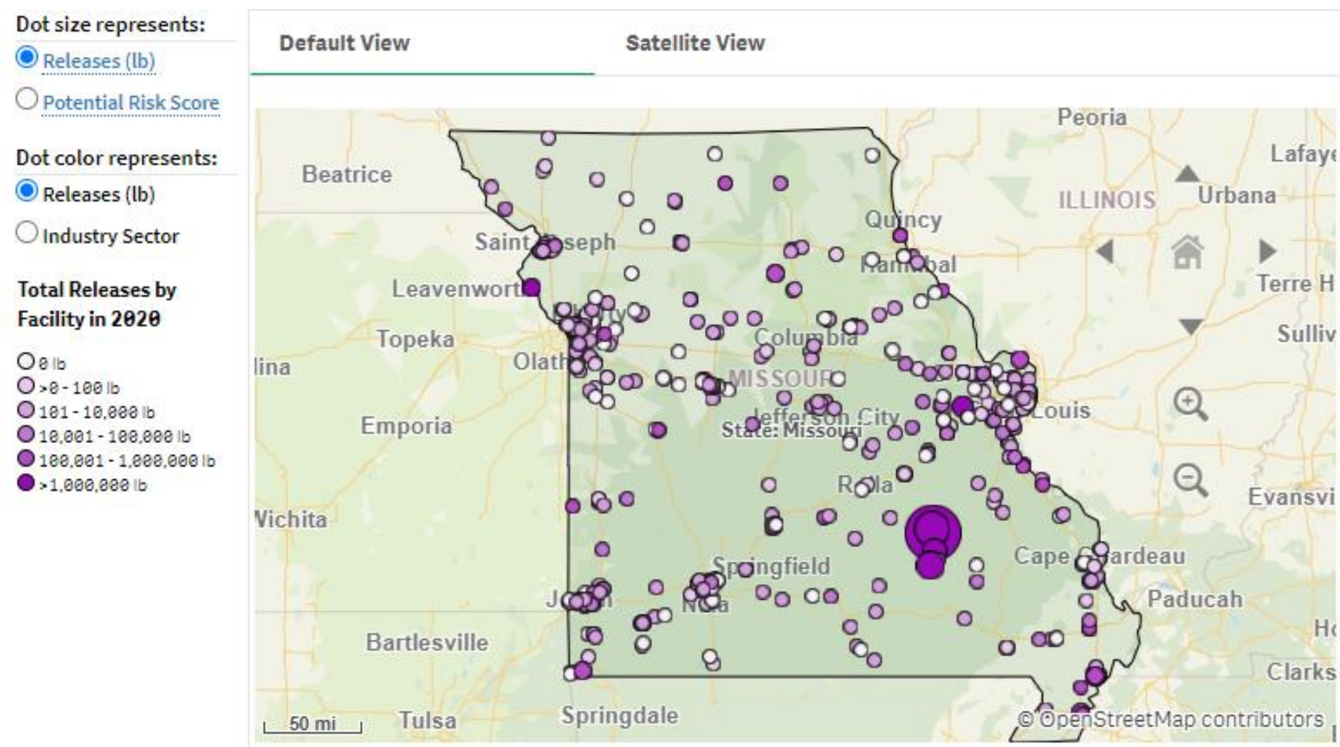
The EPA maintains a list of facilities that release the most toxic chemicals each year with the Toxics Release Inventory (TRI). The TRI is an EPA program that tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. U.S. facilities in different industry sectors must report annually how much of each chemical is released to the environment and/or managed through recycling, energy recovery and treatment. A "release" of a chemical means that it is emitted to the air or water, or placed in some type of land disposal. Facilities that report to TRI are typically larger facilities involved in manufacturing, metal mining, electric power generation, chemical manufacturing and hazardous waste treatment.

There are currently 770 individually listed chemicals and 33 chemical categories covered by the TRI Program. In general, chemicals covered by the TRI are those that cause cancer or other chronic human health effects; significant adverse acute human health effects; and significant adverse environmental effects. A list of the

monitored chemicals can be found on the EPA's website here: https://www.epa.gov/toxics-release-inventory-tri-program/tri-listed-chemicals.

The figure below shows a map if TRI facilities from Missouri's most recent reporting in 2020. There are 552 facilities within the state that have reported toxic releases of 206 chemicals. Missouri's top 10 facilities for 2020 are shown in **Table 3.72**. The top 10 chemicals released in the State are shown in **Table 3.73**. Releases include spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment. The information is recorded by onsite and off-site releases. The onsite releases are based upon detected releases of material into the air, land and water. Off-site releases are divided between publicly own treatment works and disposal.

Figure 3.153. Map of Reported TRI Facilities in Missouri, 2020



Source: EPA TTI Toxics Tracker: https://www.epa.gov/toxics-release-inventory-tri-program

Table 3.72. Top 10 Facilities in Missouri Showing Greatest Releases (2020), ***(All figures are in pounds)***

Facility	County	On-Site Release					Off-Site Release		Total**
		Underground Injection Wells; Landfills	Air	Point Source	Surface Water	Land	POTW*	Disposal	
Buick Mine/Mill	Iron	-	3,574	692	1,954	11,340,000	858	-	11,347,078
Brushy Creek Mine/Mill	Reynolds	-	1,072	118	433	6,754,000	-	-	6,755,623
Buick Resource Recycling Facility	Iron	4,225,110	618	7,783	849	-	1,835,375	-	6,069,735
Sweetwater Mine/Mill	Reynolds	-	900	71	3,349	3,874,000	-	25	3,878,345
Fletcher Mine/Mill	Reynolds	-	1,119	53	1,004	3,212,000	-	-	3,214,176
Associated Electric Cooperative Inc New Madrid Power Plant	New Madrid	-	5	237,395	3,327	1,240,510	-	-	1,481,237
Ameren Missouri Labadie Energy Cntr.	Franklin	-	7	513,307	391	960,185	-	-	1,473,890
Iatan Generating Station	Platte	1,230,489	26,156	15,917	5	110	-	-	1,272,677
Biokyowa Inc	Cape Girardeau	-	250	250	1,170,777	-	-	3,847	1,175,124
Ford Motor Company – Kansas City Assembly Plant	Clay	-	12,524	1,036,050	-	-	10,268	27,409	1,086,250

Source: EPA, Toxic Resources Inventory (TRI) Database, 2020

Notes: *Releases to POTWs (publicly owned treatment works) of metals or metal compounds only

**None of the values in this table include Dioxin or Dioxin-like compounds

Table 3.73. Top 10 Chemicals Reported in Missouri (2020), (*All figures are in pounds*)

Chemical	On-Site Release					Off-Site Release		Total**
	Underground Injection Wells; Landfills	Air	Point Source	Surface Water	Land	POTW*	Disposal	
Lead Compounds	2,580,607	6,341	8,279	1,530	12,137,956	1,204,432	124,154	16,063,299
Zinc Compounds	543,384	11,108	27,725	6,760	8,946,338	452,126	122,295	10,109,737
Barium Compounds	2,136,282	58	14,837	9,672	2,487,958	51,659	1,024	4,701,490
Copper Compounds	98,846	1,717	2,129	333	4,343,084	67,674	14,433	4,528,216
Nitrate Compounds	-	682	633	3,252,076	3,010	5,395	911,374	4,173,170
Chromium Compounds	393,090	324	2,127	377	34,504	792,455	290,175	1,513,053
N-Hexane	-	233,664	1,113,979	-	-	1	26,102	1,373,746
Styrene	-	926,022	368,381	-	-	173	24,964	1,319,540
Ammonia	1,670	195,967	693,776	138,062	1,320	11,566	150,880	1,193,242
Hydrogen Fluoride	-	232,253	812,262	5	-	-	5	1,044,525

Source: EPA, Toxic Resources Inventory (TRI) Database, 2020

Note: *These numbers include transfers of non-metals to POTWs (publicly owned treatment works), but transfers of non-metals to POTWs are considered off-site treatment, not releases to the environment, and are NOT included in the Total Releases column

Volkswagen AG's Clean Air Act Violation, 2016 - In 2016, the United States settled complaints against Volkswagen AG, et al., stemming from the company's violations of the Clean Air Act. VW sold approximately 590,000 diesel vehicles equipped with emissions defeat devices in the U.S.

Flint Water Crisis, 2015 – Lead seepage into the drinking water in Flint, Michigan caused a massive public health crisis that led President Obama to declare a state of emergency. Old corrosive pipes caused lead to leach into the City's water supply. Inadequate treatment and testing of the water resulted in a series of major water quality and health issues for Flint residents.

Acid Mine Drainage in East Fork Little Chariton River, 2006 - Coal mining operations occurred in the East Fork Little Chariton River Watershed until 1955. Eroding coal waste areas near Huntsville and in other areas of the watershed resulted in acid mine drainage (AMD) that degraded water quality in the river. Missouri identified 48.5 miles of the East Fork Little Chariton River as impaired by sulfate for the public drinking water supply beneficial use, causing the Missouri Department of Conservation (MDC) to add this waterbody to Missouri's 2006 impaired waterbodies list.

For information regarding historical incidents involving air and water pollution in Missouri, see **Section 3.3.14** Hazardous Materials Release.

Probability of Future Hazard Events

Environmental health concerns are on the rise, with recent scientific data emphasizing the long-term impacts that air and water pollution can have on the ecology of affected areas. With continued enforcement of regulatory standards for airborne releases and discharges to waterways, routine emissions by industrial facilities are relatively easy to monitor and control. However, the potential always remains for unauthorized dumping and releases and for failure of systems to control industrial discharges, resulting in potential environmental emergencies.

Changing Future Conditions Considerations

Higher temperatures lead to an increase in allergens and harmful air pollutants. For instance, longer warm seasons can mean longer pollen seasons – which can increase allergic sensitizations and asthma episodes and diminish productive work and school days. Exposure to pollen has been linked to asthma attacks and increases in hospital admissions for respiratory illness. Medical costs linked with pollen exceed $3 billion every year, with nearly half of those costs being linked to prescription medicine. Higher temperatures associated with climate change can also lead to an increase in ozone.

According to the National Climate Assessment, climate change is projected to harm human health by increasing ground-level ozone and particulate matter air pollution in some locations. Factors such as increased global temperatures and increases in the intensity and frequency of wildfire events can affect ozone and particulate matter concentrations, respectively. Increasing these different factors could lead to elevated health problems associated air pollution, such as diminished lung function, increased hospital admissions and emergency room visits for asthma, and increases in premature deaths.

According to the CDC, estimates that assume no change in regulatory controls have ranged from 1,000 to 4,300 additional premature deaths nationally per year by 2050 from combined ozone and particle health effects. Health-related costs based on current ozone air pollution levels exceeding national standards have been estimated at $6.5 billion (in 2008 U.S. dollars) nationwide, based on a U.S. assessment of health impacts from ozone levels during 2000–2002.

The frequency of heavy precipitation events has already increased for the nation as a whole and is projected to increase in all U.S. regions. In addition to the immediate health hazards associated with extreme precipitation events when flooding occurs, other hazards can often appear once a storm has passed. For example, buildings damaged during hurricanes are especially susceptible to water intrusion. Populations living in damp indoor environments can experience increased prevalence of asthma and other upper respiratory tract symptoms, such as coughing and wheezing, as well as lower respiratory tract infections such as pneumonia, respiratory syncytial virus (RSV), and RSV pneumonia.

Floodwaters contain many things that could be potentially harmful to people's health. Floodwater could contain things such as human or animal waste, household, medical, and industrial hazardous waste (chemical, biological, and radiological), coal ash waste that can contain carcinogenic compounds such as arsenic, chromium, and mercury, and other contaminants that can lead to illness.

Drought also poses risks to public health and safety. Drought conditions may increase the environmental exposure to a broad set of health hazards including wildfires, dust storms, extreme heat events, flash flooding, degraded water quality, and reduced water quantity. Dust storms associated with drought conditions contribute to degraded air quality due to particulates and have been associated with increased incidence of coccidioidomycosis (valley fever), a fungal pathogen, in Arizona and California.

Globally, climate change is expected to threaten food production and certain aspects of food quality, for example, nutritional value of some foods is projected to decline. Elevated atmospheric CO2 is associated with decreased plant nitrogen concentration, and therefore decreased protein, in many crops, such as barley, sorghum, and soy. The nutrient content of crops is also projected to decline if soil nitrogen levels are suboptimal, with reduced levels of nutrients such as calcium, iron, zinc, vitamins, and sugars.

Farmers may need to use more herbicides and pesticides because of increased growth of pests and weeds, as well as decreased effectiveness and duration of some chemicals. Farmers, farmworkers, and consumers will be increasingly exposed to these substances and their residues, which can be toxic.

State Vulnerability Overview

Environmental incidents involving air and water pollution would likely impact a more localized area; however, long-term effects on the environment in the impacted area could linger for many years.

Although Missouri has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. In July 1993, for example, St. Joseph's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt wastewater treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and excessive air pollutants associated with smog in large metropolitan areas create public health problems.

State Estimates of Potential Losses

According to the Missouri Department of Natural Resources 2020 Missouri Integrated Water Quality Report, "cost information pertaining to water quality improvement and protection efforts is difficult to calculate exactly, but can be estimated to some degree. While the Department tracks its own programmatic costs, those representatives of municipal, private, and industrial treatment facility

operations, and in some cases, the implementation of BMPs, are typically not readily available. Economic benefits, in monetary terms, resulting from water protection efforts are even more difficult to calculate." An overview of the amount of funding the department spends on various aspects of water pollution control and prevention includes the following:

- USGS ambient water quality monitoring network: $1.3 million annually. Annual costs for permit issuance averaged approximately $3.2 million for fiscal years 2017 and 2018. On average, approximately $12 million is spent each year for other facets of water pollution control and administrative support.
- Non-Point Source (NPS): $3.6 and $3.7 million was spent on NPS projects in state fiscal years (SFYs) 2016 and 2018, respectively. Approximately $200,000 – 300,000 is awarded annually for planning such projects.
- Soil and Water Conservation Program: an average of $24.1 million each year is distributed directly to landowners to address agricultural NPS pollution and to conserve and protect the quality of water resources in agricultural landscapes. Over FFYs 2014 to 2015, a total of $48.3 million was spent on SWCP conservation practices aimed at reducing soil runoff from farmland.
- Missouri's Clean Water State Revolving Fund (CWSRF) makes low interest loans available to eligible recipients for designing and constructing publicly-owned wastewater systems and other eligible projects including, but not limited to, stormwater infrastructure, non-point source projects, and water conservation or reuse. During the 2019 reporting period, the Department entered into nine direct loans and four grants for a total of $80,979,585 in CWSRF binding commitments (funding by EPA matching funds).
- The Public Drinking Water Branch operates a Source Water Protection Program (SWPP) that is designed to keep drinking water safe for Missouri's Residents. Cost associated with implementing SWPP activities are approximately $145,000 per year.

Hazard Impact on Future Growth and Development

Throughout the State, continuing suburban development impacts streams in several ways. Shortening and culverting of channels leads to the direct loss of streams and riparian areas. The increase in impervious surface area in the surrounding watershed leads to unnatural hydrograph patterns, with lower baseflow and higher stormflow. The altered channel and higher peak flows can increase erosion, while the runoff from the impervious surface carries increased levels of sediment and various chemicals from the urban environment. Elevated nutrient levels or bacterial contamination is also likely if individual or community domestic sewage systems are not well maintained.

Risk Summary

There are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. Environmental disasters of significant proportions in Missouri include the following events:

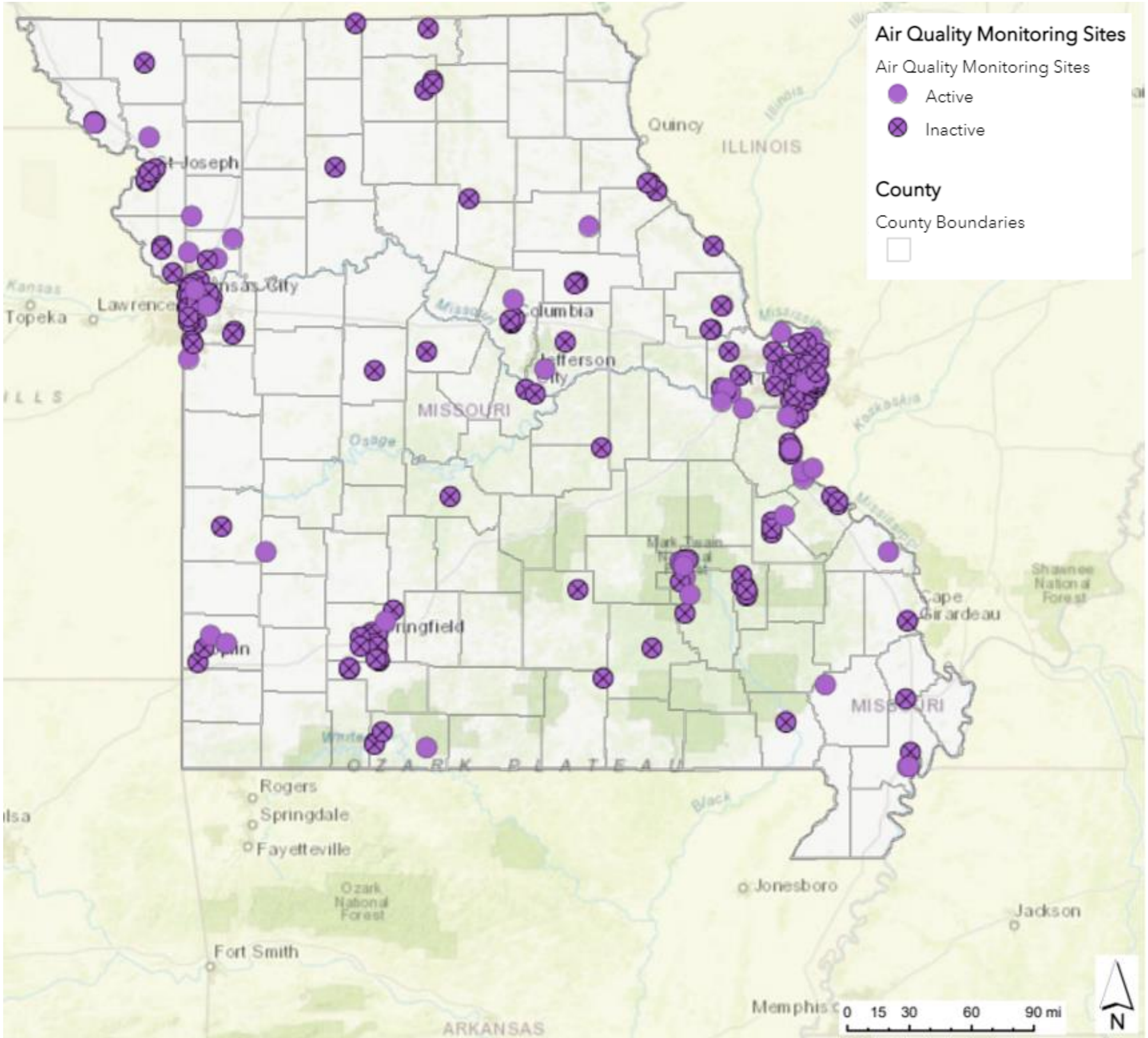
- In July 1993, St. Joseph's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt wastewater treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and excessive air pollutants associated with smog in large metropolitan areas create public health problems.

- In 1983, the town of Times Beach, located in St. Louis County, was evacuated due to dioxin contamination. Dioxin is chemical compound found to cause severe health effects when high levels of exposure occur. In the 1920s and 30s, the town was a summer resort but had since become a low-middle class town. Due to the dust problem from unpaved roads, a local waste hauler was hired to spray waste oil in and around the town on the dirt roads. The waste hauler had also been hired by a local company to dispose of toxic waste. The toxic waste came from a facility in western Missouri that had once produced Agent Orange during the Vietnam War. The hauler was unaware of the dioxin content and mixed it with the oil being sprayed. A problem first arose when 62 horses died after the mixture was sprayed in a stable to mitigate dust. On December 5, 1982, the Meramec River flooded causing an evacuation due to more than 95% of the town being under ten feet of water. On December 23, 1982, the EPA announced that dangerous levels of dioxin were found in the soil around Times Beach. By 1985, the Times Beach was evacuated and dis-incorporated. It was later found that the waste contained 2,000 times the amount of dioxin content of Agent Orange. It was the largest civilian exposure to dioxin in the county’s history.

Air Pollution

Staff in the State of Missouri Air Quality Monitoring section operates a variety of instruments at 50 active locations around the State as part of a network to monitor air pollutants known to affect people's health (See **Figure 3.154**). In addition, staff conducts special air quality studies: https://dnr.mo.gov/air/what-were-doing/air-monitoring http://dnr.mo.gov/env/esp/aqm/esp-aqm.htm.

Figure 3.154. Missouri Air Quality Monitoring Sites



Source: Missouri Department of Natural Resources
https://modnr.maps.arcgis.com/apps/webappviewer/index.html?id=d5ce711960744f74abe421312915d075

Water Pollution

The Missouri Department of Natural Resources also maintains the State's water quality management plan and has developed basin-by-basin assessments of Missouri's surface water resources. These basins may be divided into the following geographic categories: Upper Mississippi River tributaries, Missouri River tributaries north of the Missouri River, Missouri River tributaries south of the Missouri River, Lower Mississippi River tributaries, White River tributaries, and Arkansas River tributaries. For the most up to date information on water pollution go to [Water Protection Program | Missouri Department of Natural Resources (mo.gov)](https://dnr.mo.gov) .

According to the Missouri Division of Natural Resources 2016 Missouri Integrated Water Quality Report, Missouri has an area of 68,742 square miles and a population just under 6.1 million people, according to the 2016 census estimate. About half of the population is concentrated on opposite sides of the State in the Kansas City and St. Louis metro areas, leaving most of the State and its waters rural in nature.

Surface and groundwater in Missouri are quite varied in quantity and quality, corresponding closely with geology and land use. The 2020 Missouri Integrated Water Quality Report is available here: https://dnr.mo.gov/document/2020-missouri-integrated-water-quality-report-305b-report

According to the 2020 Integrated Water Quality Report, state concerns include the following:

Managing agricultural and urban runoff is an ongoing challenge in Missouri; both sources have substantial influence on the condition of water quality.

- Wastewater treatment facilities and other point source dischargers have a significant impact on water quality. Point sources are subject to NPDES permit requirements; however, pollution incidents still happen occasionally. Failing treatment systems, bypasses, accidental spills, or illicit waste disposal are some types of violations that can occur.
- Current mining operations have caused significant changes to water quality. Heavy metals such as lead and zinc may enter streams from smelters, mills, mine water, and tailings ponds.
- Facilities that generate large amounts of animal waste and manure have the potential to cause serious water pollution problems. There are 500 Class I CAFOs located in Missouri.
- Mercury levels in fish continue to impair fish consumption in Missouri waters. For 2020, totals of 844 stream miles and 27,134 lake acres were listed as impaired for mercury in fish tissue.
- Missouri's water quality standards do not include statewide nutrient criteria, but site-specific criteria have been assigned to a limited set of lakes.
- Eutrophication of state waters, particularly the recreationally important large reservoirs, is an ongoing concern.
- Additional groundwater protection measures are needed.

Identifying Pollution Hazard Areas

Local emergency management officials should identify pollution hazard areas so that in case of a natural disaster, recovery steps will not be delayed. Pollution of public drinking water, for example, can cause severe problems with reentry and recovery. If alternate sources of safe drinking water can be identified, or relocation of water intakes can eliminate polluted drinking water, then recovery can be quicker, and local resources can be used to address other problems.

With the increases in motor vehicle registrations throughout the State, the levels of nitrocarbon emissions will naturally rise. Combinations of smog and carbon monoxide levels will also increase. In sufficient quantities, these pollutants can have deleterious effects on the health of thousands of Missourians.

Problem Statement:

Using population and major transportation corridors as key indicators, the data suggests that counties at most risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

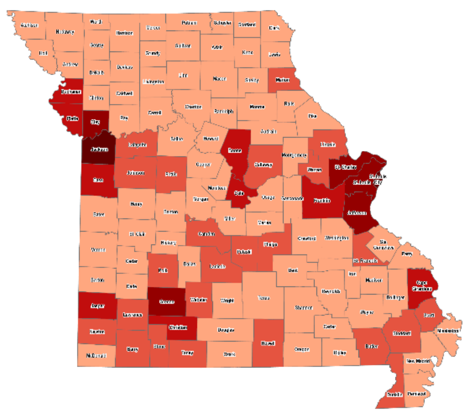
2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.15. Hazardous Materials Release (Fixed Facility and Transportation Accidents)

Description

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The category of hazardous materials release includes incidents involving substances such as toxic chemicals, fuels, nuclear wastes and/or products, and other radiological and biological or chemical agents. For the purposes of this analysis, only accidental or incidental releases of hazardous materials from two different kinds of incidents are addressed: fixed facility and transportation-related accidents.

Vulnerability



Extent/Range of Intensity

The entire State of Missouri is susceptible to this type of hazard. However, the magnitude of a hazardous materials release incident will vary in every case depending on the amount spilled or released, type of chemical, method of release, location of release, time of day, and weather conditions. Close coordination between the Missouri Department of Natural Resources, the U.S. Environmental Protection Agency (EPA), the local jurisdiction, and the spiller (responsible party) will be required to minimize the potential impacts to public health and the environment.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

The entire State of Missouri is susceptible to this type of hazard, depending on a number of factors such as the type of chemical, amount released/spilled, method of release, location of release, time of day, and weather conditions. This hazard could have a significant impact on the public health, the environment, private property, and the economy. The impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. If contamination occurs, the spiller is responsible for the cleanup actions and will work closely with the Missouri Department of Natural Resources, EPA, and the local jurisdiction to ensure that cleanup is done safely and in accordance with federal and state laws.

Changing Future Conditions Considerations

Accidental or incidental releases of hazardous materials are non-natural incidents and therefore, there are no implications for impacts from climate change. However, there is growing evidence that hazardous material releases triggered by natural hazards can pose significant risks. In these incidences, the impact of climate change is of a secondary nature. It may exacerbate the natural hazard event by triggering release of hazardous materials.

Risk Summary/Problem Statement

Using the County of Tier II Facilities and the major transportation corridors for the State as key indicators, the counties at most risk for Hazardous Materials Release are St. Louis City, Jackson, Greene, St. Charles, St. Louis County, Boone, Clay, Jefferson, Jasper, and Franklin. Mitigation strategies and limited resources would best be allocated in these counties.

Description/Location

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The category of hazardous materials release includes incidents involving substances such as toxic chemicals, fuels, nuclear wastes and/or products, and other radiological and biological or chemical agents. For the purposes of this analysis, only accidental or incidental releases of hazardous materials from two different kinds of incidents are addressed: fixed facility and transportation-related accidents. In consideration of recent worldwide and national events, incidents involving terrorism or national attacks, which involve hazardous materials of any type, are addressed in, **Section 3.3.20** Terrorism and **Section 3.3.19** Special Events.

Hazardous Materials Fixed-Facility Accident

Generally, with a fixed facility, the hazards are pre-identified. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 requires industries to report on the storage, use and releases of hazardous substances to federal, state, and local governments. Facilities in Missouri must submit an emergency and hazardous chemical inventory form to the Missouri Emergency Response Commission, their Local Emergency Planning Committee (LEPC), and local fire departments annually. The inventory forms require basic facility identification information, employee contact information for both emergencies and non-emergencies, and information about chemicals stored or used at the facility.

Table 3.74 present the number of facilities reporting hazardous material storage per county along with the number of facilities reporting storage of extremely hazardous substances (EHS), as defined by the EPA, for both 2016 and 2021. **Figure 3.155** presents the number of facilities by county for 2021.

Table 3.74. Tier II Reporting Facilities within Missouri, 2016

County	2016 No. of Tier II	2021 No. of Tier II	Change	2016 No. of Tier II with EHS	2021 No. of Tier II with EHS	Change
Adair County	41	38	(3)	9	9	0
Andrew County	31	24	(7)	4	8	4
Atchison County	37	31	(6)	13	12	(1)
Audrain County	68	56	(12)	25	17	(8)
Barry County	89	65	(24)	28	26	(2)
Barton County	38	33	(5)	11	12	1
Bates County	36	31	(5)	8	6	(2)
Benton County	44	36	(8)	4	7	3
Bollinger County	16	9	(7)	2	0	(2)
Boone County	202	216	14	57	61	4
Buchanan County	165	143	(22)	55	38	(17)
Butler County	67	29	(38)	15	13	(2)
Caldwell County	28	29	1	4	2	(2)
Callaway County	107	94	(13)	33	21	(12)
Camden County	113	84	(29)	14	11	(3)
Cape Girardeau County	102	101	(1)	28	23	(5)

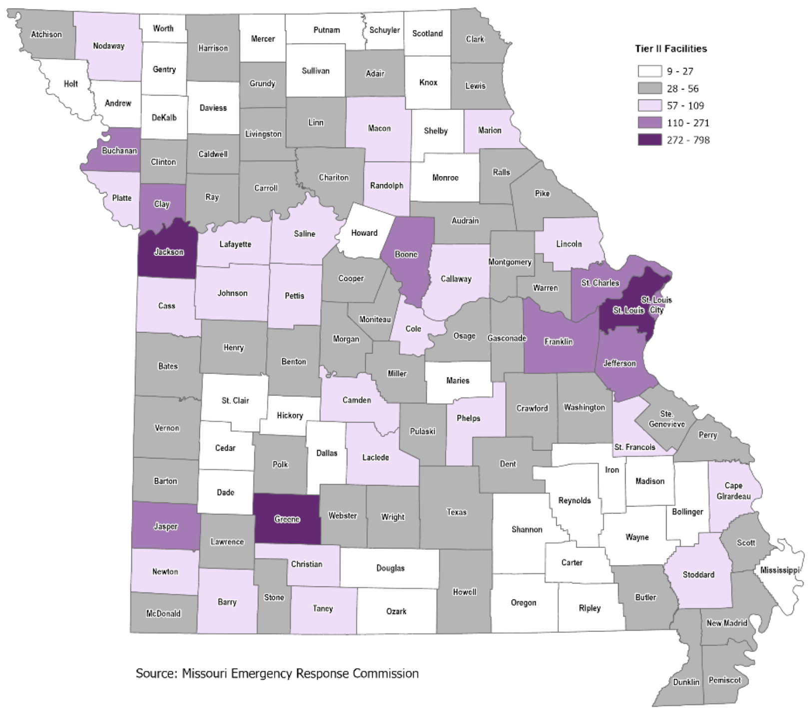
County	2016 No. of Tier II	2021 No. of Tier II	Change	2016 No. of Tier II with EHS	2021 No. of Tier II with EHS	Change
Carroll County	45	35	(10)	15	8	(7)
Carter County	17	12	(5)	0	1	1
Cass County	116	109	(7)	23	27	4
Cedar County	27	25	(2)	6	4	(2)
Chariton County	32	30	(2)	13	9	(4)
Christian County	75	71	(4)	8	8	0
Clark County	27	32	5	9	9	0
Clay County	214	195	(19)	64	60	(4)
Clinton County	36	37	1	7	7	0
Cole County	95	92	(3)	13	17	4
Cooper County	49	39	(10)	15	9	(6)
Crawford County	57	53	(4)	8	8	0
Dade County	23	14	(9)	6	5	(1)
Dallas County	23	18	(5)	1	1	0
Daviess County	31	25	(6)	7	4	(3)
DeKalb County	26	21	(5)	6	5	(1)
Dent County	30	30	0	3	2	(1)
Douglas County	13	11	(2)	3	3	0
Dunklin County	57	41	(16)	19	12	(7)
Franklin County	189	162	(27)	27	35	8
Gasconade County	35	33	(2)	5	5	0
Gentry County	26	27	1	5	9	4
Greene County	378	424	46	105	149	44
Grundy County	40	32	(8)	8	8	0
Harrison County	40	33	(7)	8	9	1
Henry County	54	41	(13)	12	10	(2)
Hickory County	21	15	(6)	0	0	0
Holt County	26	27	1	10	9	(1)
Howard County	21	16	(5)	7	6	(1)
Howell County	72	46	(26)	7	7	0
Iron County	30	22	(8)	4	7	3
Jackson County	617	523	(94)	179	189	10
Jasper County	203	167	(36)	68	18	(50)
Jefferson County	182	170	(12)	45	36	(9)
Johnson County	77	69	(8)	19	17	(2)

County	2016 No. of Tier II	2021 No. of Tier II	Change	2016 No. of Tier II with EHS	2021 No. of Tier II with EHS	Change
Knox County	18	18	0	4	4	0
Laclede County	80	72	(8)	17	9	(8)
Lafayette County	77	68	(9)	19	19	0
Lawrence County	74	52	(22)	10	6	(4)
Lewis County	34	34	0	8	6	(2)
Lincoln County	88	68	(20)	24	9	(15)
Linn County	37	33	(4)	7	7	0
Livingston County	44	39	(5)	10	8	(2)
Macon County	43	66	23	6	7	1
Madison County	18	13	(5)	2	1	(1)
Maries County	18	13	(5)	0	6	6
Marion County	71	66	(5)	14	13	(1)
McDonald County	46	32	(14)	12	11	(1)
Mercer County	27	25	(2)	11	2	(9)
Miller County	62	42	(20)	5	5	0
Mississippi County	38	26	(12)	12	3	(9)
Moniteau County	39	36	(3)	5	5	0
Monroe County	25	25	0	8	8	0
Montgomery County	48	42	(6)	18	13	(5)
Morgan County	40	33	(7)	9	10	1
New Madrid County	67	52	(15)	20	8	(12)
Newton County	89	70	(19)	21	16	(5)
Nodaway County	61	61	0	18	18	0
Oregon County	20	11	(9)	2	2	0
Osage County	52	42	(10)	11	3	(8)
Ozark County	17	11	(6)	1	2	1
Pemiscot County	46	33	(13)	11	8	(3)
Perry County	38	34	(4)	7	6	(1)
Pettis County	92	82	(10)	32	21	(11)
Phelps County	84	75	(9)	31	23	(8)
Pike County	55	49	(6)	13	9	(4)
Platte County	106	92	(14)	29	27	(2)
Polk County	57	54	(3)	15	5	(10)
Pulaski County	56	47	(9)	4	6	2
Putnam County	15	12	(3)	3	6	3

County	2016 No. of Tier II	2021 No. of Tier II	Change	2016 No. of Tier II with EHS	2021 No. of Tier II with EHS	Change
Ralls County	42	36	(6)	12	9	(3)
Randolph County	60	62	2	17	15	(2)
Ray County	47	37	(10)	12	8	(4)
Reynolds County	21	12	(9)	3	7	4
Ripley County	16	9	(7)	2	1	(1)
Saline County	80	65	(15)	33	22	(11)
Schuyler County	15	15	0	4	3	(1)
Scotland County	18	17	(1)	4	4	0
Scott County	70	49	(21)	14	9	(5)
Shannon County	17	11	(6)	0	1	1
Shelby County	31	24	(7)	3	3	0
St. Charles County	277	271	(6)	75	75	0
St. Clair County	17	14	(3)	1	3	2
St. Francois County	63	63	0	9	10	1
St. Louis County	804	228	(576)	242	77	(165)
St. Louis City*	269	798	529	90	250	160
Ste. Genevieve County	41	33	(8)	8	5	(3)
Stoddard County	72	69	(3)	15	1	(14)
Stone County	47	34	(13)	5	3	(2)
Sullivan County	26	25	(1)	10	12	2
Taney County	75	57	(18)	14	13	(1)
Texas County	60	48	(12)	7	6	(1)
Vernon County	54	38	(16)	19	8	(11)
Warren County	53	39	(14)	20	12	(8)
Washington County	32	30	(2)	3	4	1
Wayne County	26	22	(4)	3	2	(1)
Webster County	46	40	(6)	10	6	(4)
Worth County	9	9	0	2	1	(1)
Wright County	36	31	(5)	9	6	(3)
TOTAL	**8,394**	7430	(964)	**2,110**	1867	(243)

Source: Missouri Emergency Response Commission, Fixed Facilities includes bulk chemical plants, bulk petroleum plants, and manufacturing facilities.

Figure 3.155. Tier II Reporting Facilities within Missouri, 2021



Source: Missouri Emergency Response Commission

The Environmental Protection Agency (EPA) also maintains a National Priority List (NPL) which serves primarily informational purposes, identifying for the States and the public those known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation. Inclusion of a site on the NPL does not in itself reflect a judgment of the activities of its owner or operator, it does not require those persons to undertake any action, nor does it assign liability to any person. In Missouri, there are currently 33 active NPL sites. Those sites are listed in **Table 3.75** by county.

Table 3.75. Missouri Active National Priority List Sites by County, 2022

County	Site Name
Cape Girardeau County	Missouri Electric Works
Clay County	Armour Road
	Lee Chemical
Dunklin County	Bee Cee Manufacturing Co.
Franklin County	Oak Grove Village Well
	Riverfront
	Sporlan Valve Plant #1
Greene County	Compass Plaza Well TCE
	Fullbright Landfill
	Solid State Circuits, Inc
Jackson County	Conservation Chemical Company
	Lake City Army Ammunition Plant (Northwest Lagoon)
Jasper County	Oronogo-Duenweg Mining Belt
Jefferson County	Minker/Stout/Romaine Creek

County	Site Name
	Southwest Jefferson County Mining
Lawrence County	Syntex Facility, Inc
Madison County	Madison County Mines
Maries County	Vienna Wells
Newton County	Newton County Mine Tailings Site
	Newton County Wells
	Pools Prairie
Scott County	Quality Plating
St. Charles County	Weldon Spring Former Army Ordnance Works
	Weldon Springs Quarry / Plant / Pits (USDOE)
St. Francois County	Big River Mine Tailings / St. Joe Minerals Corp.
St. Louis County	Ellisville Site
	St. Louis Airport/Hazelwood Interim Storage/Futura Coatings Co.
	Valley Park, TCE
	West Lake Landfill
Washington County	Washington County Lead District - Furnace Creek
	Washington County Lead District - Old Mines
	Washington County Lead District - Potosi
	Washington County Lead District - Richwoods

Source: United States Environmental Protection Agency, National Priorities List, Superfund Program, https://www.epa.gov/superfund/national-priorities-list-npl-sites-state#MO

Hazardous Materials Transportation Accidents

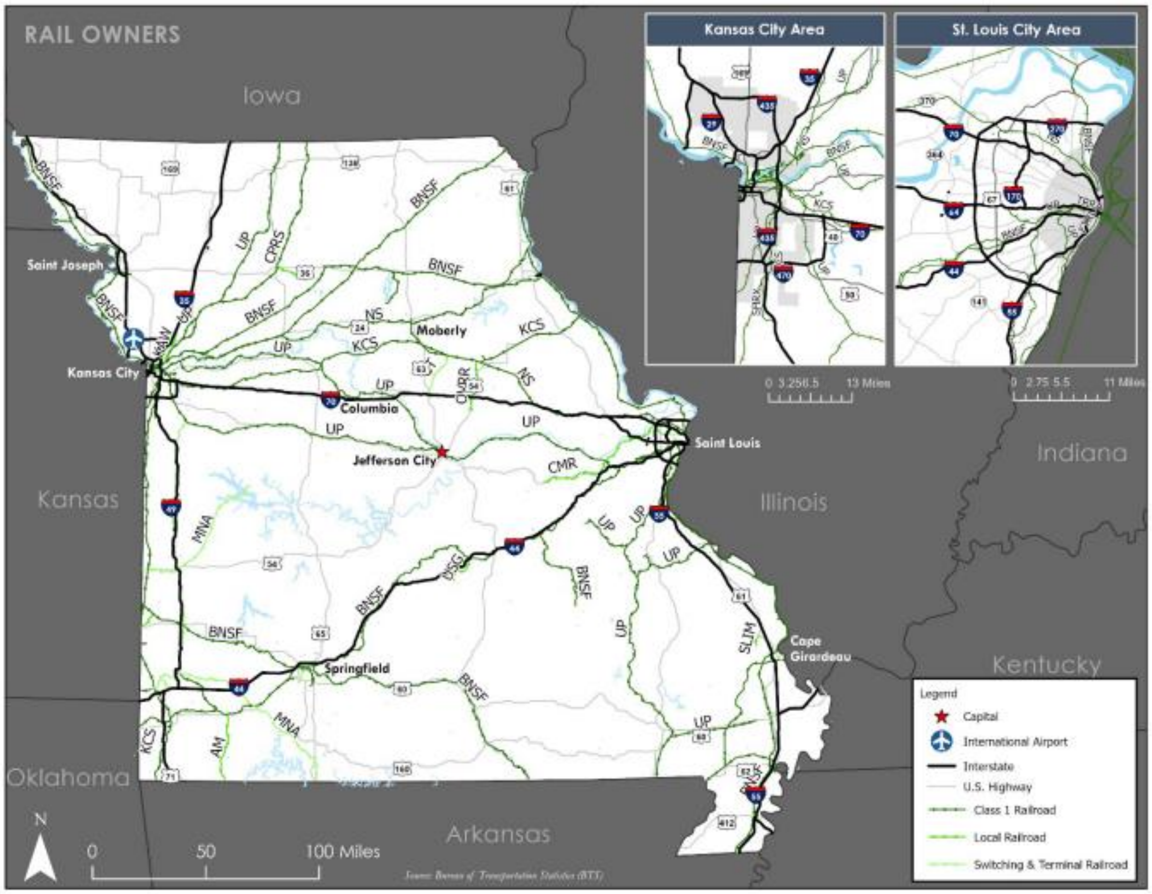
Transportation accidents address the transport of hazardous materials by rail, road, water, pipeline, and air. In these events, the exact location of a hazardous materials accident is not possible to predict. The close proximity of railroads, highways, waterways, pipelines, airports, and industrial facilities to populated areas, schools, and businesses could put a large number of individuals in danger at any time. In addition, essential service facilities, such as police and fire stations, hospitals, nursing homes, and schools near major transportation routes in the State are also at risk from potential hazardous materials transportation incidents.

Railways

The railroad systems in Missouri transport voluminous types and amounts of hazardous materials on their 5,300 miles of rails that traverse the State (see **Figure 3.156**). Though individual cars may be placarded to reveal contents such as hazardous materials, only estimates can be obtained concerning volumes of such materials, because only the interstate traffic is counted or measured. Interstate shipments are accounted for where they originate and terminate. For the 2022 Missouri State Freight and Rail Plan, a commodity flow analysis was undertaken to understand the existing and potential future demand for freight in the year 2045 across all modes. The total value of freight transported using Missouri's multimodal transportation network is forecast to grow to $1.8 T by 2045. This is an increase of 57 percent, growing by an average of $25.9 B annually from 2018 to 2045. Improving freight rail operations through targeted infrastructure projects would benefit businesses moving products and resources within Missouri by reducing train delays and speeding up shipments.

Rail is also used to transport radioactive materials. The Union Pacific route between St. Louis and Kansas City and the Norfolk Southern route from Hannibal to Kansas City are both used for large radioactive material shipments. The switching yards at St. Louis and Kansas City process more of these transcontinental trains than any other yards in the country.

Figure 3.156. Missouri Rail Freight Carriers System Map, 2022



Source: Missouri Department of Transportation
[2022 State Freight and Rail Plan Documents | Missouri Department of Transportation (modot.org)]

Roadways

Federal Highway Administration statistics indicate that 1 of 10 motor vehicles is engaged in the transport of hazardous materials of some type. Missouri is particularly at risk because of the highway system and geographical location. With Interstate highways such as I-29, I-35, I-44, I-55, and I-70, Missouri offers premium routes for commercial carriers traversing the continental United States. Even arterial highways in Missouri, such as U.S. Highways 71, 13, 63, 54, and 61 are maintained to provide more favorable traveling conditions than in other central states. In addition, U.S. Highway 36 crosses the northern counties, while U.S. Highway 60 crosses the southern counties.

Rail and truck transport is used for shipment of radioactive products and wastes across Missouri due to the locations of nuclear facilities in relation to mines and fuel processing plants. Missouri is also at the crossroads for rail and truck transport of nuclear waste to the Yucca Mountain, Nevada, test site. Truck shipments alone affect 25 different states, 266 counties, and two Indian reservations.

The federal government has finalized development of long-term repositories for spent fuel and other high-level radioactive wastes, and for transuranic (known as TRU waste), at Yucca Mountain, Nevada, and Carlsbad, New Mexico, respectively. Speculations have suggested that up to 3,600 shipments per year may go to these facilities, depending on several variables.

A large number of hazardous material shipments come from two corporations in Missouri. Covidien Medical, purchased and now merged with Medtronic, is in Maryland Heights (St. Louis County) and Tri-State Motor Transit in Joplin (Jasper County). Covidien Medical is one of the largest manufacturers of radiopharmaceuticals in the world. Tri-State is one of the largest single private carriers of radioactive materials in the world, in addition to transporting all classes of explosive materials and other toxic and hazardous materials.

Vessel

The U.S. Army Corps of Engineers indicates that over 9,000 tons of petroleum products and over 200,000 tons of chemicals and related products are shipped annually by river barge via the Missouri River between Omaha and Kansas City.

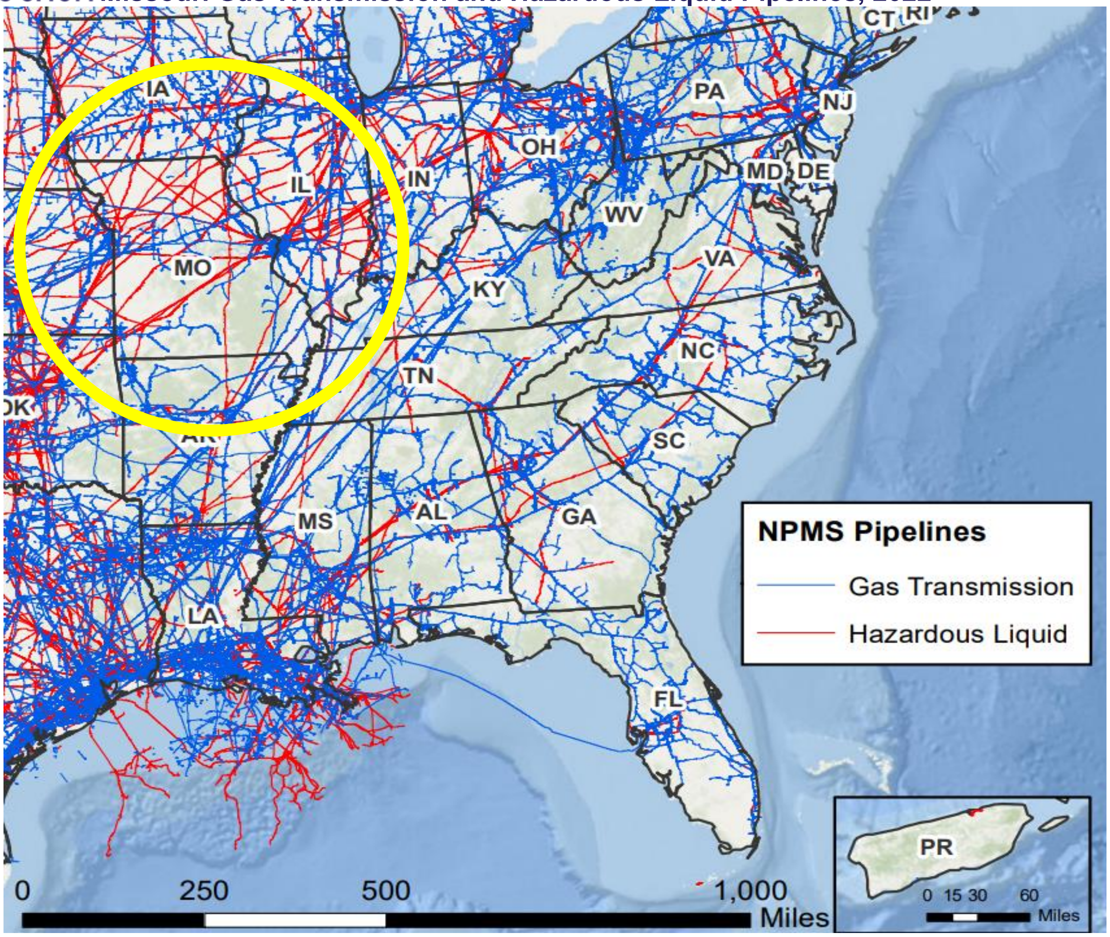
Pipeline

Pipelines in Missouri include both large-diameter lines carrying energy products to population centers, as well as small-diameter lines delivering natural gas to local businesses and residences. For the purposes of hazardous materials incidents, pipeline transport focuses on hazardous liquids, including crude oil, petroleum products, anhydrous ammonia and carbon dioxide. Within Missouri, there are approximately 1,846 miles of pipeline carrying crude oil, 1,373 miles of pipeline carrying highly volatile liquids, flammables, and toxic liquids; and 1,914 miles of pipeline carrying refined petroleum products (see **Figure 3.157**). The highest percentages of pipeline miles, according to the Missouri Incident and Mileage Overview authored by the Pipeline and Hazardous Materials Safety Administration (PHMSA), are in St. Charles County (4.9 percent), Cass County (3.6 percent), Audrain County (3.5 percent), and Johnson County (3.4 percent). These counties are located in the northern half of the State where the majority of major pipelines pass.

Air

Approximately 20 flights each day out of Lambert Airport in St. Louis carry nuclear medicines, and Tri-State Motor Transit Company of Joplin has approximately 25 shipments of high explosives each week.

Figure 3.157. Missouri Gas Transmission and Hazardous Liquid Pipelines, 2022



Source: Pipeline and Hazardous Materials Safety Administration
https://www.npms.phmsa.dot.gov/Documents/NPMS_Pipelines_Map.pdf

Extent

The entire State of Missouri is susceptible to this type of hazard. However, the magnitude of a hazardous materials release incident will vary in every case depending on the amount spilled or released, type of chemical, method of release, location of release, time of day, and weather conditions. Close coordination between the Missouri Department of Natural Resources, the U.S. Environmental Protection Agency (EPA), the local jurisdiction, and the spiller (responsible party) will be required to minimize the potential impacts to public health and the environment.

Hazardous Materials Fixed-Facility Accident

The severity of consequences is rated as moderate but may be either low or high depending on the type and amount of chemical released. This means the chemical is expected to move into the surrounding environment at a concentration sufficient to cause serious injuries and/or death, unless prompt and effective corrective actions are taken. Injuries and/or death would be expected only for personnel exposed over an extended period or when individual personal health conditions create complications.

Hazardous Materials Transportation Accident

The severity of the consequences is rated as moderate, but may be either low or high depending on the location of the accident and the time of day. This rating means injuries and/or death are expected only for exposed personnel over extended periods of time or when individual personal health conditions create complications.

Previous Occurrences

Hazardous Materials Spill Incidents

Under the Missouri Spill Bill (260.500 – 260.550 RSMo) responsible parties/spillers are required to report releases of hazardous substances to the department's 24-Hour Environmental Emergency Response (EER) Spill Line 573-634-2436 or to the National Response Center 800-424-8802. EER Duty Officers maintaining the EER Hotline provide technical assistance regarding the chemical and necessary cleanup actions, work with the responsible party/spiller to ensure that proper cleanup is completed and impact to the public health and environment is minimized, conduct notifications to various agencies, and determine if an on-site response is needed by EER staff. EER Duty Officers complete and submit an EER Incident Report on each incident reported on the 24-Hour Environmental Emergency Response Hotline or via fax from the National Response Center. Reports are recorded to the Missouri Environmental Logging Index (MERLIN), which replaced the old tracking system, the Missouri Environmental Emergency Response Tracking System (MEERTS). Both systems are available on the EER website. Once the EER Incident Report is finalized, it is made available. During the period from 2017-2021, there were 2,290 incidents reported through MEERTS for hazardous substance emergencies/releases at fixed facilities (bulk chemical plant, bulk petroleum plant, and manufacturing facilities); aircraft/airports; pipeline/pump stations; railroad/railyards; road/highway/right-of-way; and water/waterway/marinas. This is a significant increase from the period of 2012-2016, which had a total of 4,374 incidents. While the majority of counties presented with a decrease in the total number incidents, the following counties noted had increases: Platte (9), Dunklin (8), Reynolds (7), Daviess (5), Taney (5), Carter (4), Atchison (3), Pike (3), St. Louis (3), and Bates (2).

The EER Section provides a weekly report via email that summarizes the reported incidents for a given week. The EER section also provides the MERLIN and MEERTS database to the public. The databases provide specific details on all reported releases of hazardous substances such as date, county, material released, property use, incident cause, clean-up method and more. The MEERTS database reports incidents occurring on or before October 31, 2021 and MERLIN reports incidents occurring since November 1, 2021. Specific information from this database was used to prepare **Table 3.76** comparing fixed facility (bulk chemical plant, bulk petroleum plant, and manufacturing facilities); aircraft/airport; pipeline/pump station; railroad/railyard; road/highway/right-of-way; and water/waterway/marina incidents reported between 1/1/2012 and 12/31/2016 and those incidents reported between 1/1/2017 and 12/31/2021. The decrease in reported incidents is noted as red text within parentheses. Please check the website at http://dnr.mo.gov/env/esp/meerts.htm for further information.

Table 3.76. Comparison of Reported Hazardous Materials Incidents for Selected Incident Types in Missouri from 2012-2016 and 2017-2021

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ
Adair County	0	4	4	0	1	1	0	0	0	73	0	(73)	0	0	0	0	0	0	73	5	(68)
Andrew County	0	0	0	0	0	0	3	0	(3)	7	7	0	1	0	(1)	0	0	0	11	7	(4)
Atchison County	2	0	(2)	0	0	0	0	0	0	5	10	5	0	0	0	0	0	0	7	10	3
Audrain County	9	4	(5)	0	0	0	6	1	(5)	13	8	(5)	1	1	0	0	1	1	29	15	(14)
Barry County	3	3	0	0	0	0	0	1	1	16	8	(8)	6	4	(2)	0	0	0	25	16	(9)
Barton County	0	0	0	1	0	(1)	3	0	(3)	2	1	(1)	0	2	2	0	0	0	6	3	(3)
Bates County	0	0	0	0	0	0	2	2	0	7	9	2	0	0	0	0	0	0	9	11	2
Benton County	0	0	0	0	0	0	0	0	0	6	1	(5)	5	9	4	0	0	0	11	10	(1)
Bollinger County	0	0	0	0	0	0	0	0	0	2	3	1	1	1	0	0	0	0	3	4	1
Boone County	6	2	(4)	1	0	(1)	1	0	(1)	59	30	(29)	11	14	3	4	0	(4)	82	46	(36)
Buchanan County	20	11	(9)	0	0	0	33	10	(23)	19	11	(8)	2	1	(1)	3	1	(2)	77	34	(43)
Butler County	0	1	1	0	0	0	17	2	(15)	19	11	(8)	2	3	1	1	1	0	39	18	(21)
Caldwell County	0	0	0	0	0	0	4	3	(1)	7	5	(2)	0	1	1	0	0	0	11	9	(2)
Callaway County	3	2	(1)	0	0	0	0	0	0	30	12	(18)	4	4	0	0	0	0	37	18	(19)
Camden County	1	0	(1)	0	0	0	0	0	0	24	4	(20)	43	35	(8)	0	0	0	68	39	(29)
Cape Girardeau County	9	10	1	0	0	0	1	0	(1)	24	21	(3)	8	3	(5)	0	0	0	42	34	(8)
Carroll County	1	0	(1)	0	0	0	4	2	(2)	6	2	(4)	0	3	3	6	1	(5)	17	8	(9)
Carter County	0	0	0	0	0	0	0	0	0	3	6	3	0	1	1	0	0	0	3	7	4
Cass County	2	1	(1)	0	0	0	5	2	(3)	11	20	9	7	4	(3)	4	1	(3)	29	28	(1)
Cedar County	0	0	0	0	0	0	0	0	0	3	1	(2)	6	3	(3)	0	0	0	9	4	(5)
Chariton County	1	0	(1)	0	0	0	4	4	0	3	4	1	2	0	(2)	2	2	0	12	10	(2)
Christian County	2	2	0	0	0	0	2	0	(2)	27	4	(23)	3	1	(2)	0	1	1	34	8	(26)
Clark County	1	0	(1)	0	0	0	0	3	3	8	1	(7)	1	0	(1)	1	0	(1)	11	4	(7)
Clay County	5	8	3	0	1	1	28	35	7	39	22	(17)	11	4	(7)	2	1	(1)	85	71	(14)

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ
Clinton County	0	0	0	0	0	0	0	0	0	11	10	(1)	0	0	0	0	0	0	11	10	(1)
Cole County	6	4	(2)	0	0	0	14	9	(5)	19	6	(13)	16	9	(7)	5	1	(4)	60	29	(31)
Cooper County	0	0	0	0	0	0	2	1	(1)	14	8	(6)	0	1	1	0	0	0	16	10	(6)
Crawford County	2	0	(2)	0	0	0	1	0	(1)	98	16	(82)	1	0	(1)	0	0	0	102	16	(86)
Dade County	0	0	0	0	0	0	0	1	1	3	0	(3)	3	1	(2)	1	0	(1)	7	2	(5)
Dallas County	0	0	0	0	0	0	0	0	0	19	4	(15)	0	0	0	0	0	0	19	4	(15)
Daviess County	0	1	1	0	0	0	0	0	0	9	15	6	2	0	(2)	0	0	0	11	16	5
DeKalb County	0	1	1	0	0	0	0	0	0	12	4	(8)	0	0	0	0	1	1	12	6	(6)
Dent County	0	2	2	0	0	0	0	0	0	8	4	(4)	0	0	0	0	0	0	8	6	(2)
Douglas County	2	0	(2)	0	0	0	0	0	0	2	4	2	0	0	0	0	0	0	4	4	0
Dunklin County	0	0	0	0	0	0	2	5	3	11	20	9	4	0	(4)	0	0	0	17	25	8
Franklin County	4	7	3	0	0	0	11	1	(10)	150	20	(130)	6	7	1	1	0	(1)	172	35	(137)
Gasconade County	0	0	0	0	0	0	1	2	1	12	2	(10)	0	1	1	1	0	(1)	14	5	(9)
Gentry County	2	0	(2)	0	0	0	0	0	0	3	1	(2)	0	0	0	0	0	0	5	1	(4)
Greene County	7	6	(1)	1	0	(1)	15	10	(5)	114	32	(82)	5	4	(1)	0	0	0	142	52	(90)
Grundy County	1	4	3	0	0	0	2	0	(2)	2	0	(2)	1	1	0	0	0	0	6	5	(1)
Harrison County	1	0	(1)	0	0	0	0	0	0	10	9	(1)	2	1	(1)	2	0	(2)	15	10	(5)
Henry County	1	0	(1)	0	0	0	0	0	0	9	2	(7)	4	3	(1)	0	0	0	14	5	(9)
Hickory County	0	0	0	0	0	0	0	0	0	2	2	0	4	1	(3)	0	0	0	6	3	(3)
Holt County	2	1	(1)	0	0	0	0	1	1	10	13	3	0	0	0	1	0	(1)	13	15	2
Howard County	0	0	0	0	0	0	0	0	0	6	1	(5)	2	1	(1)	1	0	(1)	9	2	(7)
Howell County	0	3	3	2	0	(2)	3	1	(2)	21	4	(17)	0	0	0	0	0	0	26	8	(18)
Iron County	2	0	(2)	0	0	0	3	1	(2)	5	7	2	0	1	1	1	0	(1)	11	9	(2)
Jackson County	32	27	(5)	1	0	(1)	211	131	(80)	121	52	(69)	21	19	(2)	5	4	(1)	391	233	(158)
Jasper County	21	14	(7)	0	1	1	6	1	(5)	63	33	(30)	1	0	(1)	3	3	0	94	52	(42)

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ
Jefferson County	9	3	(6)	0	0	0	15	16	1	356	42	(314)	13	9	(4)	8	8	0	401	78	(323)
Johnson County	3	2	(1)	1	0	(1)	4	1	(3)	5	11	6	1	1	0	4	0	(4)	18	15	(3)
Knox County	0	0	0	0	0	0	0	4	4	9	0	(9)	1	0	(1)	0	0	0	10	4	(6)
Laclede County	1	0	(1)	0	0	0	1	0	(1)	37	20	(17)	0	0	0	0	0	0	39	20	(19)
Lafayette County	1	0	(1)	0	0	0	3	4	1	22	16	(6)	0	0	0	0	2	2	26	22	(4)
Lawrence County	1	4	3	0	0	0	3	1	(2)	28	11	(17)	2	0	(2)	2	0	(2)	36	16	(20)
Lewis County	0	0	0	0	0	0	0	0	0	21	6	(15)	7	3	(4)	0	0	0	28	9	(19)
Lincoln County	1	1	0	0	0	0	1	3	2	10	2	(8)	2	2	0	1	0	(1)	15	8	(7)
Linn County	0	0	0	0	0	0	1	3	2	13	13	0	0	0	0	0	0	0	14	16	2
Livingston County	0	1	1	0	0	0	0	2	2	6	3	(3)	0	0	0	0	0	0	6	6	0
Macon County	5	1	(4)	0	0	0	3	2	(1)	23	16	(7)	7	2	(5)	1	0	(1)	39	21	(18)
Madison County	0	1	1	0	0	0	0	0	0	2	1	(1)	1	1	0	1	0	(1)	4	3	(1)
Maries County	1	0	(1)	0	0	0	0	0	0	17	0	(17)	0	0	0	0	0	0	18	0	(18)
Marion County	28	21	(7)	0	1	1	6	1	(5)	79	13	(66)	7	1	(6)	1	0	(1)	121	37	(84)
McDonald County	6	2	(4)	0	0	0	0	1	1	20	15	(5)	2	1	(1)	1	2	1	29	21	(8)
Mercer County	0	0	0	0	0	0	4	1	(3)	2	3	1	0	0	0	0	0	0	6	4	(2)
Miller County	1	0	(1)	0	0	0	1	0	(1)	7	6	(1)	11	7	(4)	0	0	0	20	13	(7)
Mississippi County	0	0	0	0	0	0	0	0	0	9	15	6	8	2	(6)	0	0	0	17	17	0
Moniteau County	7	2	(5)	0	0	0	1	3	2	0	0	0	0	1	1	1	0	(1)	9	6	(3)
Monroe County	0	0	0	0	0	0	4	2	(2)	11	2	(9)	3	1	(2)	0	0	0	18	5	(13)
Montgomery County	1	0	(1)	0	0	0	1	1	0	35	10	(25)	0	0	0	0	0	0	37	11	(26)
Morgan County	0	0	0	0	0	0	0	0	0	5	5	0	9	5	(4)	0	0	0	14	10	(4)
New Madrid County	6	1	(5)	0	0	0	3	0	(3)	26	12	(14)	5	2	(3)	0	0	0	40	15	(25)
Newton County	0	3	3	0	1	1	1	2	1	42	31	(11)	0	1	1	2	0	(2)	45	38	(7)
Nodaway County	0	0	0	0	0	0	0	0	0	4	5	1	1	1	0	0	0	0	5	6	1

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ
Oregon County	0	0	0	0	0	0	1	0	(1)	3	2	(1)	1	0	(1)	0	0	0	5	2	(3)
Osage County	0	0	0	0	0	0	3	3	0	17	2	(15)	1	1	0	1	0	(1)	22	6	(16)
Ozark County	1	0	(1)	0	0	0	0	0	0	3	4	1	1	1	0	0	0	0	5	5	0
Pemiscot County	3	0	(3)	0	0	0	4	1	(3)	15	13	(2)	3	6	3	0	0	0	25	20	(5)
Perry County	3	1	(2)	1	1	0	1	1	0	14	8	(6)	3	3	0	0	0	0	22	14	(8)
Pettis County	13	8	(5)	0	0	0	5	3	(2)	12	5	(7)	2	1	(1)	6	1	(5)	38	18	(20)
Phelps County	3	2	(1)	0	0	0	3	0	(3)	80	39	(41)	1	2	1	0	0	0	87	43	(44)
Pike County	3	8	5	0	0	0	2	2	0	12	11	(1)	2	2	0	2	1	(1)	21	24	3
Platte County	0	1	1	3	11	8	2	6	4	15	8	(7)	1	4	3	2	2	0	23	32	9
Polk County	1	0	(1)	0	0	0	0	0	0	15	3	(12)	0	1	1	0	0	0	16	4	(12)
Pulaski County	0	0	0	0	0	0	1	0	(1)	27	24	(3)	2	0	(2)	0	0	0	30	24	(6)
Putnam County	0	0	0	0	0	0	1	0	(1)	4	0	(4)	0	0	0	0	0	0	5	0	(5)
Ralls County	7	2	(5)	0	0	0	1	1	0	62	11	(51)	6	3	(3)	0	0	0	76	17	(59)
Randolph County	1	0	(1)	0	0	0	5	9	4	14	1	(13)	0	1	1	1	0	(1)	21	11	(10)
Ray County	1	2	1	0	0	0	3	3	0	3	2	(1)	1	3	2	0	0	0	8	10	2
Reynolds County	0	0	0	0	0	0	0	0	0	2	8	6	0	1	1	0	0	0	2	9	7
Ripley County	1	1	0	1	0	(1)	0	0	0	4	1	(3)	0	0	0	2	0	(2)	8	2	(6)
Saline County	2	5	3	0	0	0	3	2	(1)	11	10	(1)	2	0	(2)	1	0	(1)	19	17	(2)
Schuyler County	0	0	0	0	0	0	0	0	0	12	4	(8)	1	0	(1)	0	1	1	13	5	(8)
Scotland County	0	0	0	0	0	0	1	1	0	1	3	2	0	0	0	1	0	(1)	3	4	1
Scott County	5	1	(4)	1	0	(1)	12	1	(11)	21	12	(9)	4	4	0	3	0	(3)	46	18	(28)
Shannon County	0	0	0	0	0	0	1	0	(1)	4	1	(3)	0	0	0	0	0	0	5	1	(4)
Shelby County	0	0	0	0	0	0	1	3	2	7	8	1	1	0	(1)	2	0	(2)	11	11	0
St. Charles County	5	9	4	0	1	1	6	0	(6)	105	44	(61)	13	23	10	3	1	(2)	132	78	(54)
St. Clair County	0	0	0	0	0	0	0	0	0	11	12	1	1	0	(1)	0	0	0	12	12	0

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ	2012-2016	2017-2021	Δ
St. Francois County	2	2	0	0	0	0	11	1	(10)	27	11	(16)	7	3	(4)	2	0	(2)	49	17	(32)
St. Louis County	28	38	10	14	8	(6)	40	47	7	84	88	4	62	53	(9)	12	9	(3)	240	243	3
St. Louis City*	22	11	(11)	1	1	0	74	25	(49)	40	40	0	46	8	(38)	0	1	1	183	86	(97)
Ste. Genevieve County	2	4	2	0	0	0	11	2	(9)	14	8	(6)	6	9	3	4	2	(2)	37	25	(12)
Stoddard County	8	1	(7)	1	0	(1)	17	11	(6)	16	16	0	4	0	(4)	2	0	(2)	48	28	(20)
Stone County	0	0	0	0	0	0	0	0	0	7	5	(2)	13	3	(10)	0	0	0	20	8	(12)
Sullivan County	1	1	0	0	0	0	1	0	(1)	3	3	0	1	0	(1)	0	0	0	6	4	(2)
Taney County	2	3	1	0	0	0	0	0	0	14	8	(6)	3	13	10	0	0	0	19	24	5
Texas County	0	1	1	0	0	0	1	0	(1)	14	5	(9)	0	0	0	0	0	0	15	6	(9)
Vernon County	5	6	1	0	0	0	1	0	(1)	11	8	(3)	1	1	0	0	0	0	18	15	(3)
Warren County	1	0	(1)	0	0	0	1	0	(1)	48	5	(43)	3	5	2	0	0	0	53	10	(43)
Washington County	1	0	(1)	0	0	0	0	2	2	27	17	(10)	2	1	(1)	0	0	0	30	20	(10)
Wayne County	3	1	(2)	0	0	0	4	1	(3)	9	4	(5)	2	2	0	0	2	2	18	10	(8)
Webster County	1	1	0	0	0	0	0	2	2	31	11	(20)	0	1	1	0	1	1	32	16	(16)
Worth County	0	0	0	0	0	0	0	0	0	1	0	(1)	0	0	0	0	0	0	1	0	(1)
Wright County	2	1	(1)	0	0	0	2	1	(1)	14	6	(8)	2	0	(2)	0	0	0	20	8	(12)
TOTAL	346	270	(76)	29	27	(2)	655	404	(251)	2770	1199	(1571)	464	339	(125)	110	51	(59)	4374	2290	(2084)

Source: Missouri Department of Natural Resources; Missouri Environmental Emergency Response Tracking System (MEERTS). Fixed Facilities includes bulk chemical plants, bulk petroleum plants, and manufacturing facilities.

The Missouri Department of Natural Resources' role in emergency response is to minimize damages in a hazardous substance emergency, with the highest priority being the protection of people and then the environment.

The department's mandate to address environmental emergencies includes "any chemical, petroleum, or other material spilled on to the land, water, or atmosphere" that might impact the public health/safety and/or the environment. The Missouri "Spill Bill"* (Section 260.500 to 260.550 RSMo) requires the department to maintain a 24-hour EER Hotline, and provides the authority to initiate a cleanup or provide cleanup oversight for chemical releases.

Pipeline Incidents

Pipeline incidents are also tracked through the Pipeline and Hazardous Materials Safety Administration (PHMSA). The table below presents significant incidents reported to PHMSA for a 20-year period. Significant Incidents include (1) fatality or injury requiring in-patient hospitalization; (2) $50,000 or more in total costs, measured in 1984 dollars; (3) highly volatile liquid releases of 5 barrels or more or other liquid releases of 50 barrels or more; or (4) liquid releases resulting in an unintentional fire or explosion.

Table 3.77. Pipeline Incidents reported to PHMSA, 2002-2021

Year	Number of Incidents	Fatalities	Injuries	Total Cost as Reported
2002	2	0	1	$156,621
2003	3	1	2	$5,030,772
2004	4	0	0	$456,795
2005	4	0	0	$1,616,110
2006	6	0	0	$1,419,359
2007	2	0	2	$3,734,105
2008	5	0	0	$5,052,534
2009	6	0	1	$1,363,191
2010	6	0	1	$758,291
2011	2	0	0	$307,720
2012	4	0	0	$1,064,628
2013	5	1	4	$25,495,189
2014	7	0	0	$4,633,609
2015	9	0	0	$4,216,864
2016	4	0	0	$3,731,663
2017	3	0	0	$12,778,415
2018	6	0	1	$1,696,407
2019	10	0	0	$14,210,154
2020	2	0	0	$359,753
2021	5	0	1	$2,613,061
TOTAL	**95**	**2**	**13**	**$90,695,241**

Source: PHMSA; https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends

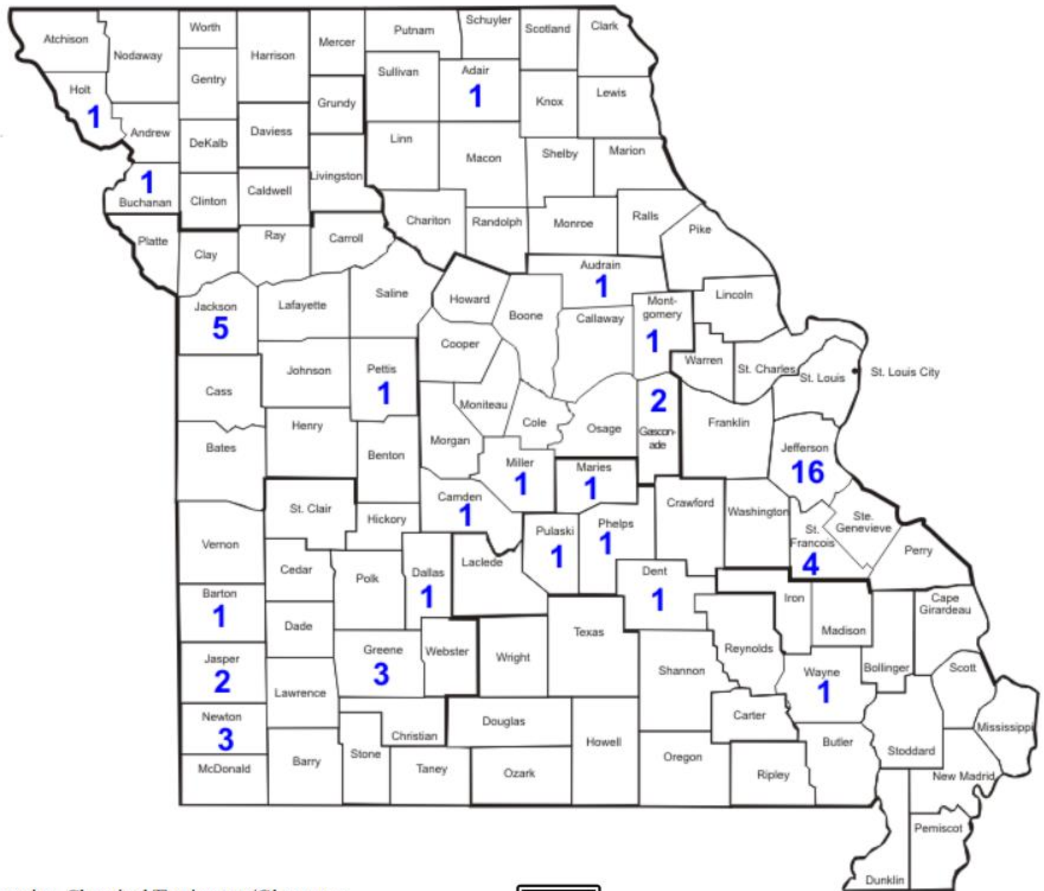
Methamphetamine Laboratory Incidents

The Missouri Highway Patrol's Division of Drug and Crime Control serves as the collection and entry point for statewide methamphetamine laboratory seizures. The data reflected in **Figure 3.158** are cumulative totals of the three types of seizure classifications occurring in each separate county for 2018. The three types of seizures are: operational laboratories, chemical/equipment/glassware and dumpsite seizures. The statistics reflected have been extracted from methamphetamine seizure incidents entered into the National Clandestine Laboratory Seizure System.

The department's involvement in the methamphetamine laboratory crisis in Missouri began in 1997. Law enforcement agencies were being inundated with large quantities of hazardous waste, chemicals and debris associated with the production of methamphetamine. At the direction of the governor, the Missouri Methamphetamine Enforcement and Environmental Protection Task Force was formed to address this and other issues related to the burgeoning problem. Numerous local, state and federal agencies and organizations banded together and, under the direction of the Meth/Special Projects Unit, created the Clandestine Drug Lab Collection Station (CDLCS) Program. Local fire service and law enforcement agencies operate collection stations throughout the State with technical and financial assistance provided by the department.

The Meth/Special Projects Unit provides a variety of supplies, personal protective equipment and air monitoring equipment to law enforcement at no cost. Examples of packaging/cleanup supplies available include 5-gallon chemical overpack buckets, hazardous materials labels, eye wash bottles, safety goggles, safety glasses, absorbent material, pH paper, hand sanitizer, etc. Personal protective equipment includes chemical protective coveralls, boot covers, nitrile gloves, air-purifying respirators, cartridges, self-contained breathing apparatus and air cylinders. Draeger pumps and tubes along with organic vapor meters and multi-gas meters have been provided to collection station operators, drug task forces and law enforcement agencies throughout the State. Inquiries concerning supplies and equipment procurement may be made by e-mail or by calling 573-526-6305. Information about the Narcotics/Vice Unit can be found at
https://www.mshp.dps.missouri.gov/MSHPWeb/PatrolDivisions/DDCC/Units/NarcoticsViceUnit/narcoticsViceUnit.html http://www.dnr.mo.gov/env/esp/meth-special-projects.htm

Figure 3.158. Missouri Methamphetamine Laboratory Incidents, 2018



Map includes Laboratories, Chemical/Equipment/Glassware seizures, and Dumpsites. These numbers reflect the incidents as reported to EPIC NSS. Report ran by MSHP on 01-24-2019

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Source: Missouri Highway Patrol, Methamphetamine Statistics, https://www.mshp.dps.missouri.gov/MSHPWeb/Publications/Reports/2018StatewideLabIncidents.pdf

Probability of Future Hazard Events

For the noted five-year periods from 2012 to 2016 and 2016 to 2021, there was an annual average of 87 and 68 fixed facility incidents, respectively. For the transportation-related incidents, the annual average was significantly higher at 980 and 492, respectively.

Changing Future Conditions Considerations

Accidental or incidental releases of hazardous materials are non-natural incidents and therefore, there are no implications for impacts from climate change. However, there is growing evidence that hazardous material releases triggered by natural hazards can pose significant risks. In these incidences, the impact of climate change is of a secondary nature. It may exacerbate the natural hazard event by triggering release of hazardous materials.

State Vulnerability Overview

The entire State of Missouri is susceptible to this type of hazard, depending on a number of factors such as the type of chemical, amount released/spilled, method of release, location of release, time of day,

and weather conditions. **Figure 3.155** presented a comparison of the number of facilities reporting hazardous material storage per county.

This hazard could have a significant impact on the public health, the environment, private property, and the economy. The impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. If contamination occurs, the spiller is responsible for the cleanup actions and will work closely with the Missouri Department of Natural Resources, EPA, and the local jurisdiction to ensure that cleanup is done safely and in accordance with federal and state laws.

Local government (county or municipal) is more often directly impacted by hazardous materials incidents than state or federal government. Local responders are generally the first on scene for any incident. Therefore, they have the responsibility for treating any injured victims and transporting them to a hospital for more complete medical care. Also, local first responders have the initial responsibility for controlling exposure of emergency workers and the public to any radioactive materials and to contain the spread of radioactive contamination as much as possible. While cleanup of any actual spill of radioactive materials rests with the shipper (in most cases), local responders may be required to provide site control for several hours until the responsible parties arrive on the scene.

Every day, hundreds of trucks with chemical tanks traverse the State on the thousands of streets, roads, and highways. Every day, dozens of chemical cargos cross the State on the railroads. These trucks and railcars constitute potential hazards on wheels. In addition, every day, the fixed facilities that store and use chemicals have the potential for accidents. During an accidental release of toxic chemicals or other emergencies where air quality is threatened, the toxics heavier than air settle on the ground and the people in proximity can breathe these toxics and be affected; the toxics lighter than air spread for several miles and impact distant people.

The State of Missouri has three hazardous substance cleanup and disposal companies currently under state contract to provide services to the department as needed. Use of the contract is preferred for all state government agencies and optional for all local governmental agencies. Some of the contractors provide services only to specific parts of Missouri and others provide services statewide. Services available from the contract include emergency response, including personnel and specialized equipment, on-site technical management of clean-up activities and disposal of hazardous wastes. This hazard could have a significant impact on the public health, the environment, private property, and the economy.

State Estimates of Potential Losses

The impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. If contamination occurs, the spiller is responsible for the cleanup actions and will work closely with the Missouri Department of Natural Resources, EPA, and the local jurisdiction to ensure that cleanup is done safely and in accordance with federal and state laws.

As mentioned, it is difficult to determine the potential losses to existing development because of the variable nature of a hazardous materials spill. For example, a spill of a toxic airborne chemical in a populated area could have great potential for loss of life and by contrast, the spill of a very small amount of a chemical in a remote agricultural area where remediation of soil would be easier could be less costly.

For the purposes of this discussion, the materials needed for a very small spill of a less hazardous chemical in an easily remediated area are listed below in **Table 3.78**. The cost for the essential personnel and equipment are taken from the current State of Missouri contract for Hazardous Substance Cleanup and Disposal Services (CS220142001-CS220142004).

Table 3.78. Potential Cost Estimate for HAZ-MAT Spill Remediation

Associated Costs:	Cost per hour/unit	Number of Hours/Units	Total Cost
Project Manager	$90.00	8	$720.00
Equipment Operator	$124.59	8	$996.72
Response Vehicle	$250.00	1	$250.00
Track Hoe	$600.00	1	$600.00
Environmental Tech	$98.55	8	$788.40
Duct tape	$7.63	6	$45.78
Haz Cat Kit	$150.00	1	$150.00
PPE - Level B Protection	$245.00	3 staff @ 1 day	$735.00
Vermiculite (19 lb bag)	$30.00	4	$120.00
55 Gallon Drum	$95.00	20	$1,900.00
95 Gallon Overpack Drum	$285.00	20	$5,700.00
Total			**$12,005.90**

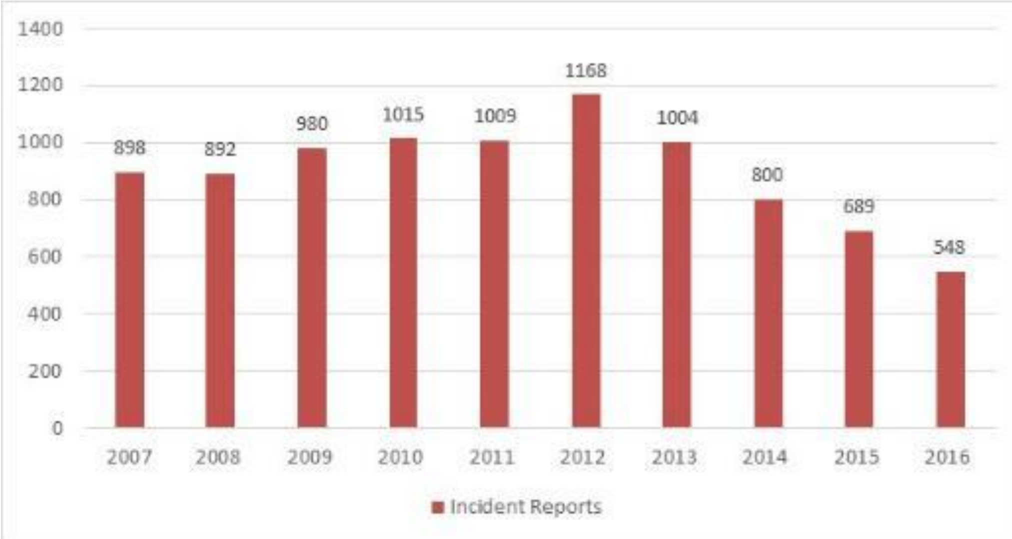
Source: The maximum cost for the essential personnel and equipment are taken from the current State of Missouri contracts for Hazardous Substance Cleanup and Disposal Services (CS220142001-CS220142004).

As previously noted, the planning team obtained information from the Missouri Department of Natural Resources Environmental Logging Index (MERLIN) and the Missouri Environmental Emergency Response Tracking System (MEERTS). According to MERLIN and MEERTS, during the last 10 years (2012-2021), Emergency Response has received an average of 833 incidents each year at fixed facilities (bulk chemical plant, bulk petroleum plant, and manufacturing facilities); aircraft/airports; pipeline/pump stations; railroad/railyards; road/highway/right-of-way; and water/waterway/marinas. **Figure 3.159** provides the yearly incidents reported through 2016, additional date information was not available for 2017-2021.

To estimate a potential cost, the estimated $12,005.90 cost per incident was then applied to the average annual number of reported incidents of 833 to calculate an average annual minimal cost. The annual cost of remediation of spills is calculated as follows: 833 average annual incidents X $12,005 per incident = $10,000,915. The majority of the cost of chemical clean-ups is borne by the party responsible for the spill, in some instances private, for-profit companies.

Because the nature of this hazard is so variable, it is difficult to create a potential dollar loss estimate for each county or for any geographic region. The damage that would be expected would be based on the type of chemical released, weather conditions, location of the spill, size of the spill, etc.

Figure 3.159. Hazardous Substances Emergencies/Releases Reported to MEERTS (2007-2016)



Source: Missouri Department of Natural Resources; Missouri Environmental Emergency Response Tracking System (MEERTS).

Hazard Impact on Future Growth and Development

As the infrastructure and population of Missouri increase along with industries and the number and type of hazardous chemicals stored and transported through the State, the amount of potential losses will increase. Because of the nature of the hazard, it is not possible to determine a geographic variability in future potential loss.

Increased use and transport of materials across the country also creates serious problems for emergency services personnel. Many factors can increase the magnitude of an otherwise simple transportation accident into an incident of potential hazard to high numbers of people. Following are potential factors to be considered:

- Over 14,000 different chemicals are estimated as being shipped by the various transportation modes. Some types of highly toxic chemicals do not require placarding if shipped in quantities of less than 1,000 pounds, even though lesser quantities could devastate a small town.
- Only a few emergency response organizations in the larger cities and counties near the more metropolitan areas have had training for handling peacetime radiological problems. With recent federal grants and programs in place to provide funding for training, exercises, and equipment for state Homeland Security Response Teams and local responders, the general capabilities of hazardous materials response personnel and teams statewide is expected to improve.

Risk Summary

Any disaster or emergency incident, such as an earthquake or a flood, could result in additional concerns when it involves hazardous materials. For example, during the floods of 1993, a large propane tank farm in St. Louis was threatened by rising floodwaters, forcing evacuations of nearby residents in several areas. Another hazardous materials incident related to the 1993 floods involved an on-going ammonia release from the La Roche Industries, Inc., facility near Crystal City, Missouri, caused by power failure and failure of the cooling system on a large ammonia tank, which ultimately resulted in off-gassing of ammonia through the tank's pressure relief check valves. The ammonia cloud over the plant led to a declaration of restricted

air space in the plant vicinity for several days. In addition, thousands of chemical containers ranging from household products and 55-gallon drums to 10,000-gallon fuel storage tanks were displaced statewide as a result of the flood damage. A federal disaster declaration was issued, the Federal Response Plan (FRP) was implemented, and Emergency Support Function #10—Hazardous Materials Annex was activated to support the statewide response to hazardous materials incidents like these and others that resulted from the flooding.

Each emergency event will need to be evaluated on an incident-specific basis, and top priority must be given to the protection of the public, then the environment, and property.

Tier II Forms are filed and maintained by the Missouri Emergency Response Commission at SEMA. Site-specific plans are on file with each county's local emergency planning commission. Transportation and evacuation routes are addressed in each county emergency operations plan. Regional Coordinators with SEMA serve as liaisons to local jurisdictions for emergency management activities including emergency operations plan development and revision, training and exercises. There are nine regional coordinators providing assistance to Missouri's 114 counties and their associated jurisdictions, and the independent City of St. Louis. A map of the nine areas is included in **Section 3.5.7**, Terrorism, which correspond with the Missouri State Highway Patrol troops.

Problem Statement:

Using the County of Tier II Facilities and the major transportation corridors for the State as key indicators, the counties at most risk for Hazardous Materials Release are St. Louis City, Jackson, Greene, St. Charles, St. Louis County, Boone, Clay, Jefferson, Jasper, and Franklin. Mitigation strategies and limited resources would best be allocated in these counties.

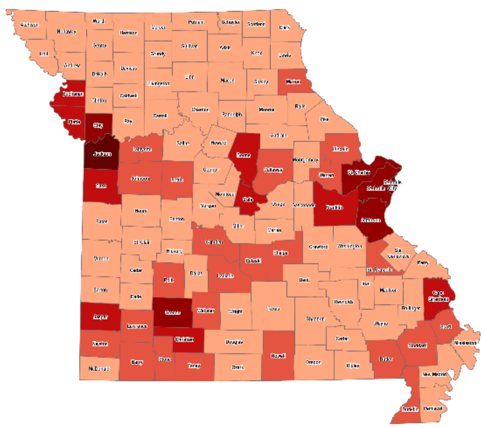
The 2022 State Freight and Rail Plan identified the challenges and needs across the state's freight and rail transportation network, including aging infrastructure, congestion and bottlenecks, safety concerns, system capacity constraints, rural and multimodal connectivity challenges and funding challenges. Four strategies and 49 implementable actions were developed to address these needs and challenges. As related to safety and hazardous materials, one goal is focused on efficient and intelligent multimodal freight corridors: Leverage technology solutions and operational changes to improve efficiency and safety of freight movement across all modes.

2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.16. Mass Transportation

Description

Mass transportation is defined as the means, or system, that transfers large groups of individuals from one place to another. Mass transportation accidents include public airlines, railroad passenger cars, metro rail travel, tour buses, city bus lines, school buses, riverboat casinos, and other means of public transportation.

Vulnerability	Extent/Range of Intensity
	There is no uniform extent rating for a mass transportation incident, as different modes of transportation have unique characteristics. Depending on the parameters of the incident, it is reasonable to assume that a large-scale mass transportation incident involving a train derailment or a plane crash could cause hundreds of fatalities, hundreds of injuries, millions in property damage and a potentially long-term loss of service.

Probability	Severity	Location
100%	Moderate	Statewide

State Vulnerability Overview

Mass transportation systems have strict plans and protocols in place to ensure the safety and security of their passengers. Even with these protocols in place, a major accident could occur at any time. Mass transportation systems can also serve as attractive targets for terrorism, with high numbers of people congregated in small spaces and the potential for disruption in daily lives.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard. The exception would be accidents caused by precipitation or other severe weather, such as high winds.

Risk Summary/Problem Statement

Using the major transportation corridors for the State and population as key indicators, the counties at most risk for Mass Transportation incidents are Boone, Buchanan, Clay, Franklin, Greene, Jackson, Jasper Jefferson, St. Charles, and St. Louis County, as well as the City of St. Louis. Mitigation strategies and limited resources would best be allocated in these counties.

Description/Location

For the purpose of this plan, mass transportation is defined as the means, or system, that transfers large groups of individuals from one place to another. This profile addresses only transportation accidents involving people, not materials. Mass transportation accidents include public airlines, railroad passenger cars, metro rail travel, tour buses, city bus lines, school buses, riverboat casinos, and other means of public transportation.

Airlines

Missouri serves as a transportation crossroad for the United States. Missouri is centrally located in the nation making it a natural hub for many major airlines (five primary airports in the State offer commercial service) and other types of tourist and business travel. Many cross-country travelers use Missouri terminals to connect with transport changes. The state's airways, railways, and highways are used as nonstop thoroughfares as well. **Table 3.79** shows primary and non-primary commercial service airports in the State. Primary airports are classified as having more than 10,000 passengers boarding each year.

Table 3.79. Primary and Non-Primary Commercial Service Airports

Location	Airport Name	Status
St. Louis	St Louis Lambert International	Primary
Kansas City	Kansas City International	Primary
Springfield	Springfield-Branson Ntl	Primary
Columbia	Columbia Regional	Primary
Joplin	Joplin Regional	Primary
Fort Leonard Wood (U.S. Army)	Waynesville-St Robert Regional Forney Field	Primary
Branson	Branson	Commercial Service
Cape Girardeau	Cape Girardeau Regional	Commercial Service
Kirksville	Kirksville Regional	Commercial Service

Source: Federal Aviation Administration (FAA)
https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

Commercial Vehicles

Tour bus travel in the State is on the increase, and more bus traffic can be expected. The Passenger Carrier Inspection Division of the Missouri Department of Transportation has developed a comprehensive passenger carrier safety inspection program. Passenger carrier safety is a primary concern for the Division because Missouri, and especially Branson, is among the top tourist destinations in North America. Division inspectors conduct safety inspections at destinations or carrier terminals when buses do not have passengers on board.

The Passenger Carrier Inspection Division has two classifications of passenger carriers: for-hire and private. For-hire passenger carriers provide service to the general public and are required to register with the division. Private carriers provide passenger service in furtherance of a commercial enterprise. Examples include, but are not limited to, hotel courtesy buses, airport passenger shuttle services, buses operated by professional musicians, and buses for civic and other groups such as scout groups where no fees are collected.

Railroads

Amtrak, the State's major passenger rail carrier, uses tracks that cross the entire state from east to west, with stations in Hemann, Kansas City and St. Louis. Missouri also has access points to two national Amtrak routes and another regional service between St. Louis and Chicago. Although Amtrak has experienced a decline in passengers since the year 2000, it continues to carry a large number of passengers daily. Peak periods for rail companies in North America is somewhere between April and September of any given year.

Other Mass Transit

In 1993, Missouri's largest city, St. Louis, began operating a Metro transportation system. Metro operates three modes of transportation service, which include bus, rail and demand-response operations, MetroBus, MetroLink and Metro Call-A-Ride, respectively. The Metro recorded 17 million passengers boarding for fiscal year 2019 and operates in a service area that includes the City of St. Louis and St. Louis County in Missouri, and St. Clair and Monroe Counties in Illinois. The MetroBus system remains the largest component of the multi-modal system, operating with a fleet of 408 buses on 47 Missouri routes and 12 Illinois routes. MetroLink operates 87 light rail vehicles, with 27 stations in Missouri and 11 stations in Illinois. Normally, the largest numbers of people are transported during the morning and evening rush hours.

Extent

There is no uniform extent rating for a mass transportation incident, as different modes of transportation have unique characteristics. Depending on the parameters of the incident, it is reasonable to assume that a large-scale mass transportation incident involving a train derailment or a plane crash could cause hundreds of fatalities, hundreds of injuries, millions in property damage and a potentially long-term loss of service. Based on the latest available information, the severity of a mass transportation incident is rated as moderate.

Previous Occurrences

Railroads

On May 14, 1997, about 9:00 pm, a Missouri and Northern Arkansas Railroad (M&NA) train, the Cotter North local, was traveling northbound in non-signaled territory when it entered a siding track and collided with an unattended and unoccupied Branson Scenic Railway (BSR) excursion train. The collision occurred in downtown Branson, Missouri, on the M&NA Aurora Subdivision at milepost (MP) 447.3. When the collision occurred, the lead locomotive unit of the striking train derailed and caught fire. Also, both locomotive units of the parked train derailed. Both train crewmembers of the M&NA train sustained minor injuries. The costs associated with the accident were $410,625.

On July 29, 2001, an Amtrak train derailed in on a section of rural track that had been undermined by heavy rains. A locomotive and three cars derailed near Sabula in Iron County. Ten people were treated for minor injuries at local hospitals.

An Amtrak train carrying 103 people on September 29, 2005 derailed in eastern Missouri near Blackwell after striking boulders from a rockslide; approximately 20 people sustained minor injuries. The severity of the derailment was mitigated by the slow speeds required to wind through the area; slow speeds were attributed as the reason no cars were overturned.

Commercial Vehicles

Commercial motor vehicles have been involved in a significant number of Missouri traffic accidents. Statistics from the Missouri State Highway Patrol Statistical Analysis Center show that in 2020, 9.89 percent of all traffic accidents involved a commercial motor vehicle. Of fatal traffic accidents, 13 percent involved a commercial motor vehicle. A total of 120 persons were killed and 2,525 were injured in commercial motor vehicle-related accidents in 2020.

The Missouri State Highway Patrol Statistical Analysis Center tracks traffic incident statistics. **Table 3.80** shows all crashes involving commercial vehicles, including injuries, fatalities, property damage-only crashes and a percentage of annual change. The amount of crashes has reduced on an average annual basis of -2% annually.

Table 3.80. Commercial Motor Vehicle Crash Data 2002-2015

Year	Fatal Crashes	Personal Injury Crashes	Property Damage Only Crashes	Total Crashes	Total Crashes Percent Change
2002	181	3529	13014	16724	-
2003	169	3338	12689	16196	-3.26%
2004	162	3382	12899	16443	1.50%
2005	171	3368	12501	16040	-2.51%
2006	143	2935	12096	15174	-5.71%
2007	150	3051	12021	15222	0.32%
2008	115	2562	10720	13397	-13.62%
2009	89	2173	9754	12016	-11.49%
2010	95	2312	9851	12258	1.97%
2011	103	2162	9521	11786	-4.00%
2012	101	2068	8970	11139	-5.81%
2013	81	2112	9636	11829	5.83%
2014	97	2061	9928	12086	2.13%
2015	108	2326	10748	13182	8.31%
2016	121	2751	11716	14588	9.64%
2017	122	2679	11418	14219	-2.60%
2018	130	2799	12200	15129	6.01%
2019	126	2941	13128	16195	6.58%
2020	126	2601	10649	13376	-21.08%
2021	136	2989	13089	16214	17.50%

Source: Missouri State Highway Patrol Statistical Analysis Center, https://www.mshp.dps.missouri.gov/TR15Reports/850ReportMenu.htm

Airlines

Information from the Federal Aviation Administration regarding primary, non-primary commercial service and general aviation airports found at: http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/ shows that there are a total of 127 airports in Missouri that are considered public use, of which eight are considered commercial. Of these, the top five are listed below including the number of enplanements for calendar year 2020 and 2022.

Table 3.81. Top Five Airports by Number of Enplanements for 2020 and 2021

Airport	County	2020 Enplanements	2021 Enplanements	Percent Change
St. Louis Lambert International	St. Louis	3,041,765	5,070,471	66.70%
Kansas City International	Platte	2,167,616	3,795,290	75.09%
Springfield – Branson National	Greene	292,246	480,975	64.58%
Columbia Regional	Boone	51,191	79,775	55.84%
Joplin Regional	Kiowa	24,944	26,698	7.03%

Source: Federal Aviation Administration, https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

The National Traffic Safety Board records aircraft incidents involving fatalities in the United States. The NTSB records two such incident in Missouri, in 1994 and 2004. On November 23, 1994, a pilot mistakenly turned on to the wrong runway of another aircraft causing an accident. Two people were killed. On October 19, 2004, a plane flying between St. Louis and Kirksville crashed on the approach to the Kirksville Airport, killing thirteen people and injuring two.

Probability of Future Hazard Events

A major accident can occur at any time, even though all safety precautions are in place. Accidents involving commercial vehicles occur on an annual basis, however these are usually considered minor in nature. Based on the latest available information for different modes of transportation, the probability of a mass transportation accident is 100%.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard. The exception would be accidents caused by precipitation or other severe weather, such as high winds.

Changes in precipitation patterns, particularly more extreme precipitation events and drought, have the potential to affect transportation systems across the country. Storm drainage systems for highways, tunnels, airports, and city streets could prove inadequate, resulting in localized flooding. Bridge piers are subject to scour as runoff increases stream and river flows, potentially weakening bridge foundations.

State Vulnerability Overview

Mass transportation systems have strict plans and protocols in place to ensure the safety and security of their passengers. Even with these protocols in place, a major accident could occur at any time. Mass transportation systems can also serve as attractive targets for terrorism, with high numbers of people congregated in small spaces and the potential for disruption in daily lives.

State Estimates of Potential Losses

It is difficult to determine the actual risk to each county in Missouri, as no specific mass transportation studies have been conducted to date. Certainly, the counties in and surrounding the metropolitan areas of St. Louis, Springfield and Kansas City are at greater risk because of the nature of the population and the transportation hubs within each area. The Branson area would also have a greater risk because of the large numbers of tourists visiting the area and arriving by mass transportation. However, an accident could occur in any area in Missouri.

Although there are other types of mass transportation incidents, the commercial vehicle accident was chosen for the loss estimate scenario since it is the most common mass transportation incident. Using the Missouri Department of Transportation's 2015 Missouri State Highway System Traffic Crash Statistics as a basis for the number of vehicle crashes and the Federal Highway Administration's costs of a traffic crash, a potential loss estimate has been calculated. The crash numbers are for 2015 and it is assumed that 2015 was a typical year for crashes. Based on these assumptions, **Table 3.82** lists the potential costs associated with mass transportation accidents in Missouri. It is assumed that injuries are evident injuries rather than incapacitating injuries, which the FHWA estimates cause $36,000 in costs per injury. The FHWA estimates that a fatality causes $2.6 million in cost per fatality.

Table 3.82. Annual Loss Estimates for Mass Transportation Accidents (Vehicle Accidents) in 2015

Type of Vehicle	Injuries	Injury Costs	Fatalities	Fatality Costs
Bus (Small/Large)	223	$17,617,000	3	$12,000,000
Limousine	4	$316,000	0	$0
School Bus	152	$12,008,000	0	$0
Passenger Van	2,296	$181,384,000,000	30	$120,000,000
Totals	**2,523**	**$211,325,000**	**33**	**$132,000,000**

Sources: Missouri State Highway Patrol Statistical Analysis Center, 2015 data
http://www.mshp.dps.missouri.gov/MSHPWeb/SAC/Compendium/TrafficCompendium.html
FHWA Accident Costs https://safety.fhwa.dot.gov/hsip/resources/fhwasa09029/sec4.cfm

The Centers for Disease Control estimates economic losses from fatalities caused by traffic crashes. According to the CDC, traffic-related fatalities cause an estimated $981 million in economic costs per year, including $8 million in health care costs and $973 million in work loss costs.

Hazard Impact on Future Growth and Development

As the amount of tourism increases and personal travel through Missouri via mass transit increases, the number of accidents can be expected to increase. Costs increase each year as well.

Risk Summary

Missouri serves as transportation crossroads for the United States. Bus systems, passenger rail, airlines and other mass transportation systems are generally operated in a safe manner. While Missouri has a history of minor incidents involving mass transportation, these tend to have little long-term impact to those systems or the State. Impacts from these types of incidents can and have included injuries, fatalities, property damage and system disruptions.

Problem Statement:

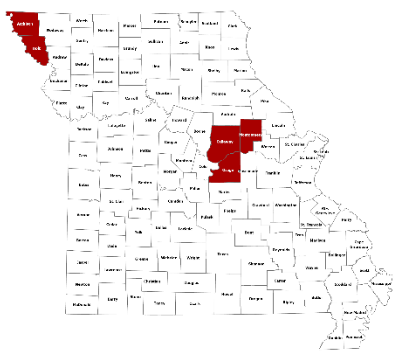
Using the major transportation corridors for the State and population as key indicators, the counties at most risk for Mass Transportation incidents are Boone, Buchanan, Clay, Franklin, Greene, Jackson, Jasper Jefferson, St. Charles, and St. Louis County; as well as the City of St. Louis. Mitigation strategies and limited resources would best be allocated in these counties.

2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.17. Nuclear Power Plants

Description

There are presently four fixed nuclear facilities or reactors that, under extreme circumstances and conditions, could pose a threat to citizens of Missouri. These four reactors fall into two categories: research reactors and commercial nuclear power reactors. The first category, research reactors, represents a hazard only to personnel or others on-site at the facility. For the second category, commercial nuclear power reactors, a worst-case scenario involving a significant release of radioactive material could force the evacuation of the general population within a 10-mile radius of the facility. A release of this magnitude could also contaminate food and water sources within a 50-mile radius.

Vulnerability	Extent/Range of Intensity
	The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Probability	Severity	Location
Less than 1%	Low to High	Atchison, Callaway, Holt, Montgomery, and Osage Counties

State Vulnerability Overview

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the State can range in severity from insignificant to a high degree of radioactive contamination within the two to 10-mile radius surrounding the facility. The most crucial concerns during a severe incident are safe evacuation and controlled access to the areas affected by a release of radioactive materials; these processes are managed under the State of Missouri Nuclear Power Plant Action Plan. In the aftermath of a radiological incident, the main concerns include the extent of property needing to be decontaminated, contaminated food sources, and the time required to reach acceptable exposure rates and to allow the safe reentry of the public. Due to their safe operation records, fixed nuclear facilities have not historically represented a high risk to the State.

Changing Future Conditions Considerations

Generally, an incident involving a nuclear reactor would not have an impact on climate change, nor would climate change have a measurable effect on the impacts of a nuclear power plant incident. An influx of population or development in the areas around the plants would create added risk.

Risk Summary/Problem Statement

Using the Counties within a 10-mile radius of nuclear plants as the key indicator, the counties as most risk from fallout are Callaway, Montgomery and Atchison. Mitigation strategies and limited resources would best be expended in these counties first.

Description/Location

There are presently four fixed nuclear facilities or reactors that, under extreme circumstances and conditions, could pose a threat to citizens of Missouri. These four reactors fall into two categories: research reactors and commercial nuclear power reactors. The first category, research reactors, represents a hazard only to personnel or others on-site at the facility. Therefore, these reactors are not included in state radiological plans involving off-site emergency preparedness. For the second category, commercial nuclear power reactors, a worst-case scenario involving a significant release of radioactive material could force the evacuation of the general population within a 10-mile radius of the facility. A release of this magnitude could also contaminate food and water sources within a 50-mile radius.

The magnitude of releases from nuclear plant sites varies depending on the nature of the accident type, reactor design, and meteorological conditions during the release. The Nuclear Regulatory Commission and FEMA have developed regulatory guidance that both the State and utility must meet to protect the health and safety of the general population within the 10-mile emergency planning zone (EPZ). Four classes of emergency action levels are used for early notification of incidents, with clear instructions for emergency organizations within the EPZ. The four emergency classifications listed in progression of severity are notification of unusual event, alert, site area emergency, and general emergency. These levels are discussed below.

- **Notification of Unusual Event**—This classification describes unusual events that are in progress or have occurred (or could) and indicates a potential degradation of the safety level of the plant. No releases of radioactive material requiring off-site response or monitoring are expected unless safety systems are further degraded.
- **Alert**—This classification describes unusual events that are in progress or have occurred that have (or could) substantially degrade the plant safety or could threaten site personnel or damage site equipment. Any offsite releases of radioactive material that could occur are expected to be minimal and far below limits established by the Environmental Protection Agency's (EPA).
- **Site Area Emergency**—This classification level describes events in progress or have occurred which have (or could) substantially degrade the plant safety or threaten site personnel or damage to site equipment. Any offsite releases are expected to be minimal and far below limits established by the EPA.
- **General Emergency**— Events are in progress or have occurred which: a) have caused (or shortly will cause) substantial reactor core damage, with the potential for uncontrolled releases of radioactive material; or, b) involve security events that deny plant staff physical control of the facility. Offsite releases can be reasonably expected to exceed EPA PAG exposure levels beyond the plant site.

Extent

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the State can range in severity from a relatively small, insignificant incident to a high degree of radioactive contamination within the two to 10-mile radius surrounding the facility. The most crucial concerns during a severe incident are safe evacuation and controlled access to the areas affected by a release of radioactive materials. In the aftermath, the main concerns are as follows: the extent of property needing to be decontaminated, contaminated food sources, and the time required to reach acceptable exposure rates and to allow the safe reentry of the public.

An incident at a nuclear power plant resulting in a "general emergency" and evacuation (one where a release from the site boundary would be expected) could have a dramatic psychological impact on the uninformed population within the evacuation zone. The utilities and the State have an active Radiological Emergency Preparedness program to prepare local jurisdictions and the general population surrounding the plant for responding to such an incident. This program includes in-depth training of resources both from the State and local jurisdictions, and regularly scheduled drills and exercises evaluated by FEMA. Extensive planning has focused on implementation of the emergency response plan for both the State and local jurisdictions. Emphasis is placed on prompt notification of emergency organizations and the public; evacuation routes; reception and care centers for evacuees; monitoring for radiological contamination; emergency worker preparedness; and public information in the form of brochures distributed to residents within the emergency preparedness zone. The State Missouri Nuclear Power Plant Accident Plan, December 2019, outlines the response to a nuclear incident with impacts within its borders. These programs are essential to the protection of the general public.

An accident involving radioactive materials could occur in Missouri from a variety of sources, including nuclear reactors, materials in transit, industrial and medical uses, and lost or stolen sources where the public could be exposed, or contaminated, with a high level of radiation. Although the chance of a nuclear power plant release is highly unlikely, radiological accidents can cause injury or death, contaminate property and valuable environmental resources, as well as disrupt the functioning of communities and their economies.

Previous Occurrences

Research Reactors

Two research reactors are located in Missouri: the Missouri S&T Reactor (MSTR) and the University of Missouri–Columbia Research Reactor (MURR). The maximum hypothetical accident from either research reactor would place at risk only personnel working at the facilities or the public within the site boundary of the respective facilities. Both research reactors have emergency plans approved by the Nuclear Regulatory Commission (NRC) that conform with multiple regulatory requirements including:

- 10 CFR 50, **Appendix E** - *Emergency Planning and Preparedness for Production and Utilization Facilities,* 2016
- 10 CFR 50.54(q) – *Conditions of Licenses*, 2021
- NRC Regulatory Guide 2.6 (revision 2), *Emergency Planning for Research and Test Reactors and Other Non-Power Production and Utilization Facilities*, 2017
- ANSI/ANS-15.16, *Emergency Planning for Research Reactors*, 2015

The current emergency plan for MSTR is dated March 2, 2022 – Revision 9. The current emergency plan for MURR is dated January 3, 2019 – Revision 20.

The MSTR is a water-moderated pool-type reactor licensed to operate at 200 kilowatts. The MSTR is used for training and research purposes. Because the reactor is mainly used for training, it is not operated for long periods of time. The reactor is located on the Missouri University of Science and Technology campus in Rolla, Missouri. Due to the low power of licensing (200 kilowatts), prevailing standards and guidelines do not require the establishment of an emergency planning zone. Therefore, no classification higher than a "site area emergency" has been included in the MSTR emergency plans.

The MSTR has been in operation since 1961 and has never had an incident that would be considered an emergency action level. The reactor is available for use by students, faculty and outside researchers.

The MURR is a 10-megawatts pressurized water-moderated pool-type reactor with a containment building. The MURR is used to provide research, training, and services to the four campuses of the University of Missouri system as well as other universities, government agencies, and private industry, and operates 6.5 days per week, 52 weeks per year. In operation since 1967, the reactor averages 8,060 hours of operation per year (155 hours per week) at peak flux due to the service work that it performs. The reactor is located on a 550-acre tract of land south of the University of Missouri–Columbia campus on Providence Road. The MURR has an emergency planning zone encompassing the area within a 150-meter radius from the exhaust stack (see **Figure 3.160**). There are no credible accidents identified for the MURR facility that would result in radiological effluents exceeding the Protective Action Guides (PAG) at the Emergency Planning Zone (EPZ) boundary or exceeding Alert Action Levels as defined for the site boundary. The reactor has an impeccable record with over 50 years without incident.

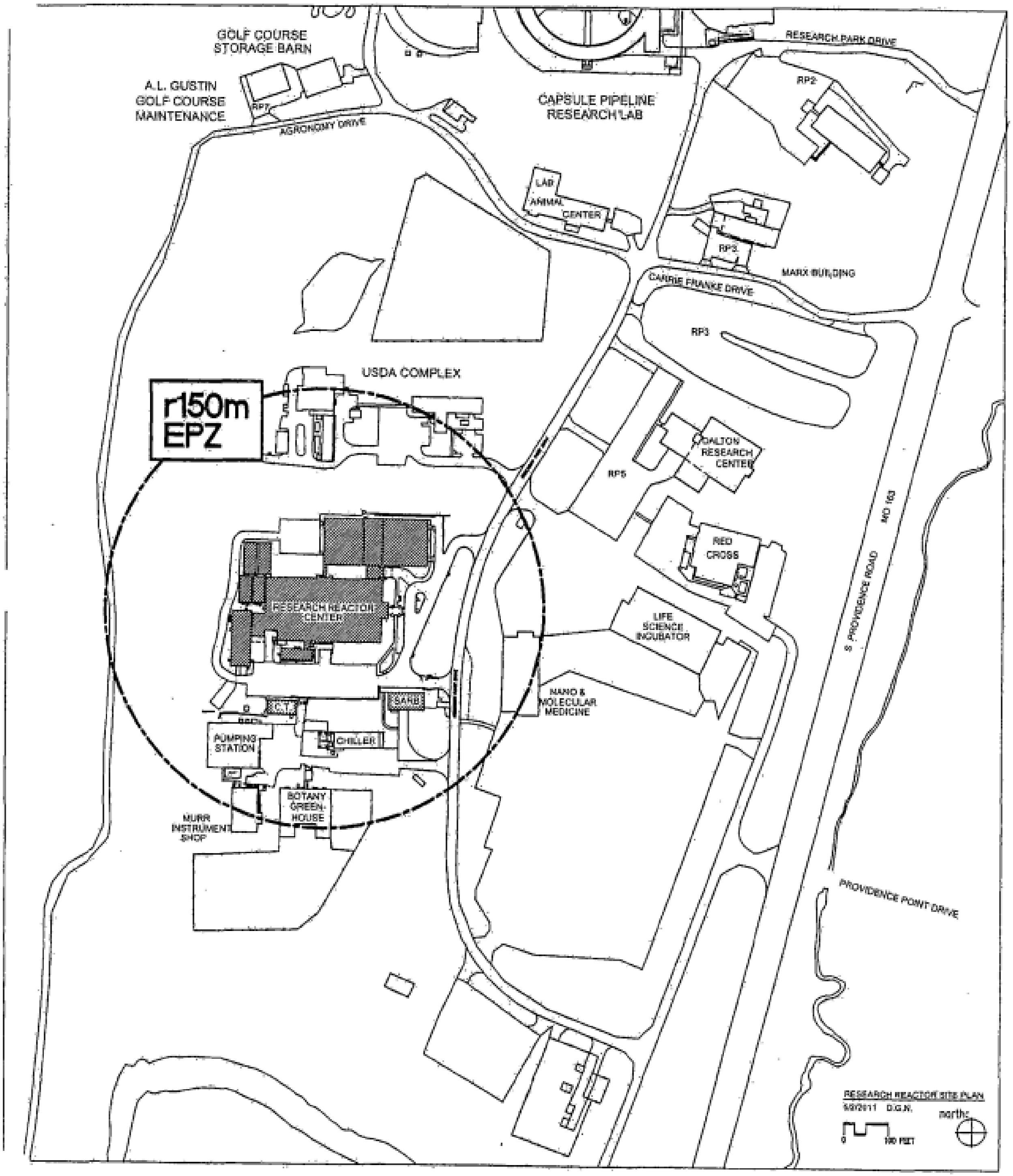
Commercial Nuclear Power Reactors

Two commercial nuclear power reactors could have an impact on the health and safety of Missouri citizens. These reactors are the Callaway Energy Center and the Cooper Nuclear Station, both of which are used for electrical power generation. Both utilities have emergency plans that conform to NUREG-0654, FEMA-REP-1 Rev.1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants. The utilities and the State are required to demonstrate annually various elements of preparedness through radiological emergency drills evaluated by inspectors representing FEMA and the NRC.

The **Callaway Energy Center (CEC)** consists of one unit with a pressurized water reactor capable of providing 1,190 megawatts of electricity. The physical plant is located in Callaway County, Missouri, and is owned and operated by Ameren Missouri. The 525-acre site is located 10 miles southeast of Fulton, 25 miles northeast of Jefferson City, 5 miles north of the Missouri River, and 100 miles west of St. Louis. The area within a ten-mile radius of the CEC site lies within four counties; approximately 60% lies in Callaway County, 20% in Montgomery County, 20% in Osage County, and approximately 1% in Gasconade County.

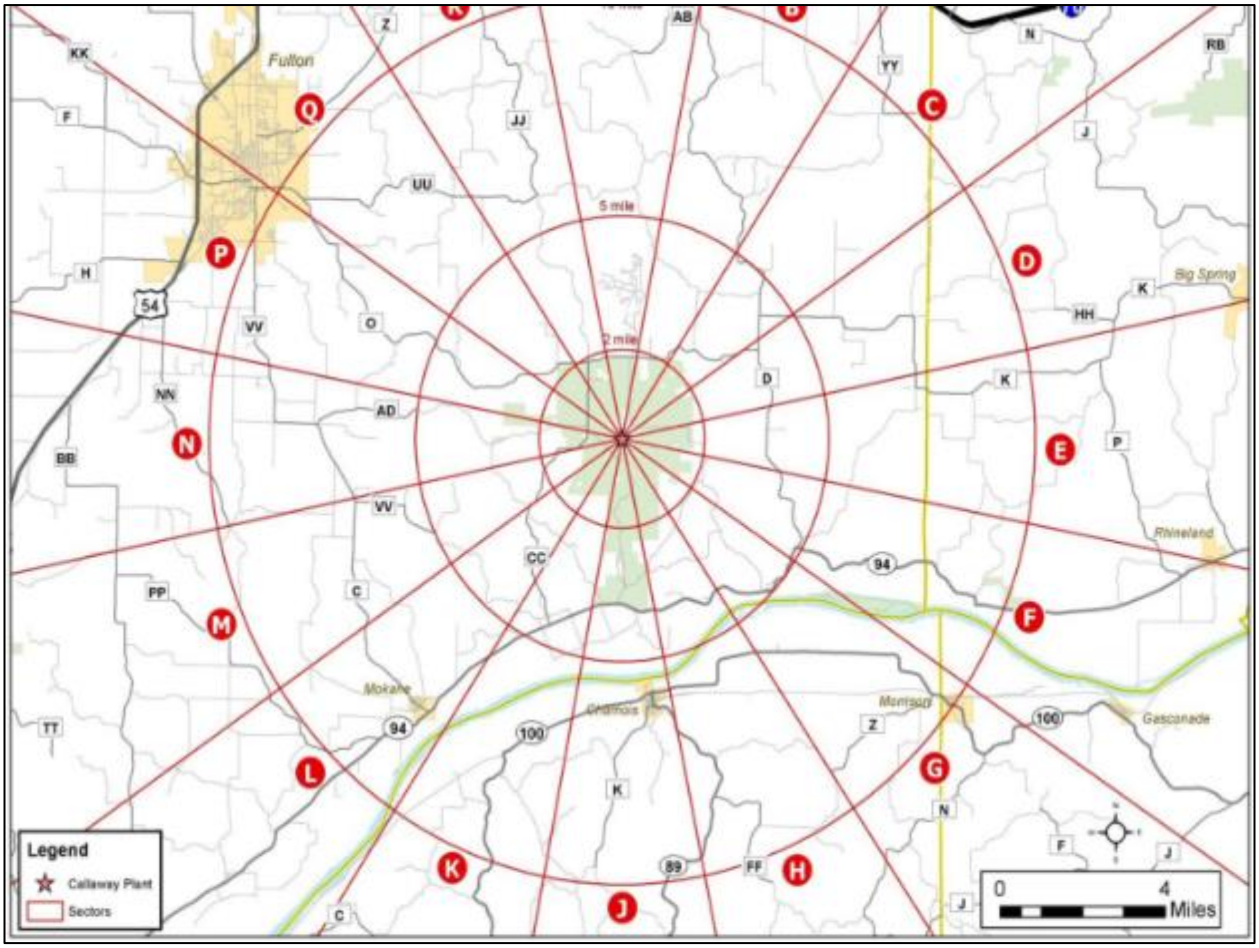
The population within the 2.5-mile radius of the plant is approximately 100 residents. Approximately 8,000 people reside within a 10-mile radius of the plant, according to the 2010 census. The plume exposure pathway has been expanded beyond the 10-mile radius to include the City of Fulton (population 12,800). Thus, the population within the plume exposure pathway is approximately 20,000. Any noticeable fluctuations in the region would be of very short duration and can primarily be attributed to lodging facilities and recreational areas. Land within a five-mile radius of the plant site is mostly rural/undeveloped. **Figure 3.161** illustrates the emergency planning zone for the Callaway Nuclear Power Plant. The plant began operating in December 1984. The plant's operating license was renewed by the Nuclear Regulatory Commission in 2015, extending its life to the year 2044.

Figure 3.160. Emergency Planning Zone for MURR



Source: MURR Emergency Plan, Revision 17, 2014

Figure 3.161. Emergency Planning Zone for Callaway Nuclear Power Plant

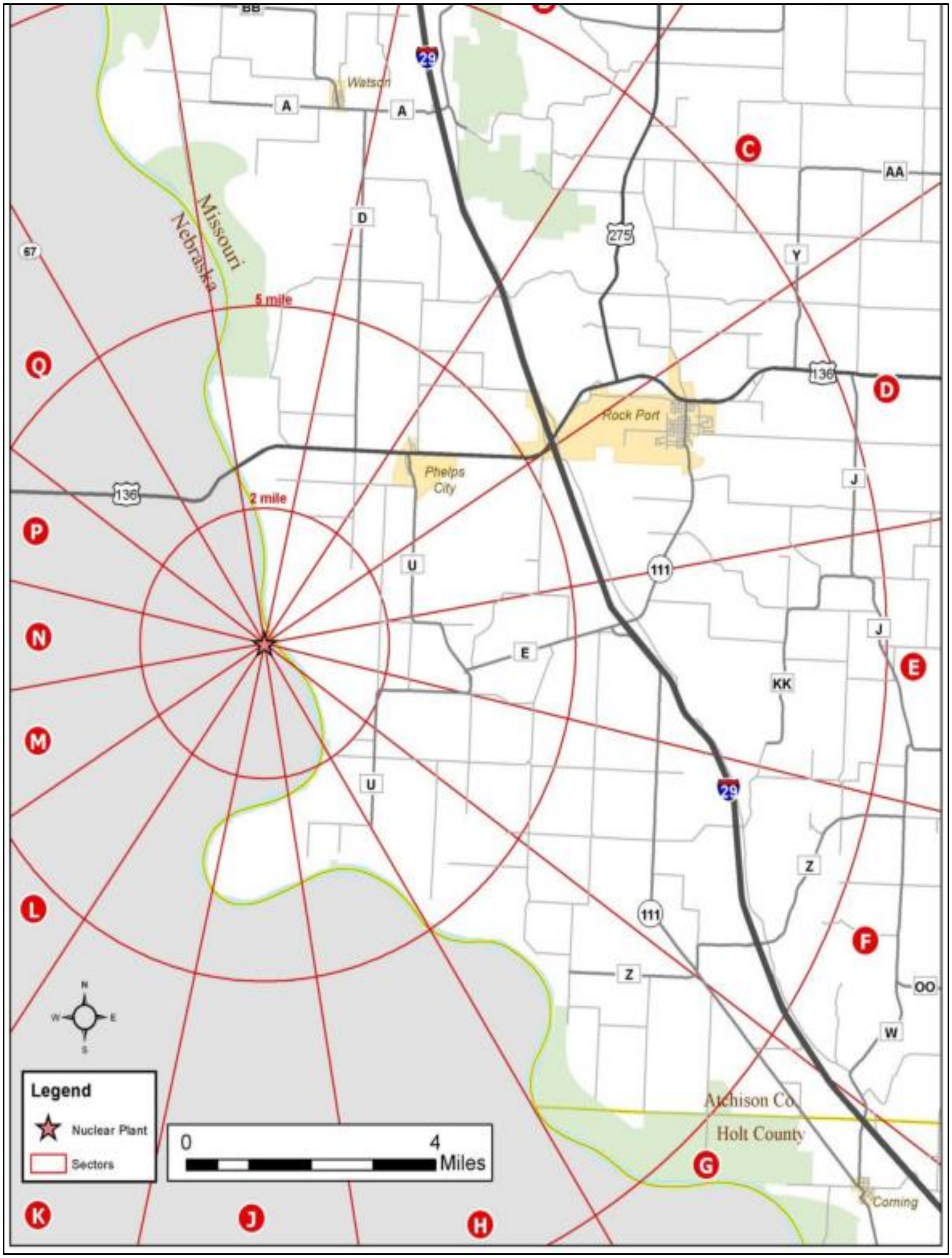


Source: Missouri Nuclear Power Plant Accident Plan, December 2019

The **Cooper Nuclear Station** is a direct-cycle boiling water-type reactor and at full power, the station generates 815 megawatts of electricity. Commissioned in July 1974, the facility is operated by the Nebraska Public Power District. The plant is located on the Nebraska side of the Missouri River in Brownville, Nebraska, approximately seven miles southwest of Rock Port, Missouri. The emergency planning zone within the Missouri side of the river is predominantly rural land, except for the towns of Rock Port, Phelps City, Langdon, and Watson.

Atchison County is primarily affected by the emergency planning zone (see **Figure 3.162**) and is intersected by several major highways, including Interstate 29, U.S. Highway 136, U.S. Highway 275, and Missouri Highway 111. The total population at risk from a radiological incident in Atchison County is as follows: no people within 2 miles; approximately 286 people within 5 miles; and approximately 2,110 people within 10 miles.

Figure 3.162. Emergency Planning Zone for Cooper Nuclear Station



Source: Missouri Nuclear Power Plant Action Plan, December 2019

Probability of Future Hazard Events

Historically, due to their safe operation records, fixed nuclear facilities have not represented a high risk to the State. The Reactor Safety Study conducted by the NRC rated the chances of a major nuclear disaster as very low (a probability of one in one million per plant operating year). The report concluded that the worst accident type that could affect a nuclear power plant would be one resulting in a meltdown, which could be expected to occur once in 20,000 years of reactor operation. The report also stated that a meltdown would likely cause less than one fatality or injury. This low hazard rating is due to diverse and redundant barriers and numerous safety systems in the plant, the training and skills of the reactor operators, testing and maintenance activities, all the added safety engineered instrumentation used to monitor and shut down nuclear plant systems before any severe damage occurs, and the regulatory requirements and oversight of the U.S. Nuclear Regulatory Commission. The probability is thus noted as <1-percent.

Changing Future Conditions Considerations

Generally, an incident involving a nuclear reactor would not have an impact on climate change, nor would climate change have a measurable effect on the impacts of a nuclear power plant incident. An influx of population or development in the areas around the plants would create added risk.

The production of nuclear power requires access to large volumes of water to cool the reactor and a supply of energy to move the water. For this reason, nuclear power plants are typically sited near large bodies of water, often seas or estuaries. It is this attachment to water that makes nuclear power vulnerable to changing future conditions.

One cause for concern is floods. All nuclear power plants are designed to withstand a certain level of flooding based on historical data, but these figures do not take changing climate conditions into account. Floods due to heavy rain are likely to increase in frequency. Loss of power, loss of communications, blockage of evacuation routes and equipment malfunction are all safety issues associated with flooding and nuclear power plants.

Heat waves are another serious concern, for two reasons. One, the colder the cooling water entering a reactor, the more efficient the production of electricity. And two, once the cooling water has passed through the system it is often discharged back where it came from in a much warmer state. Heat waves may to lead to a shut down or reduction in power production due to regulations governing receiving water temperatures and the protection of aquatic ecosystems.

The final concern is drought. Climate models predict droughts will become longer and larger in the future. Prolonged drought could impact water levels causing issues for water intake pipes that are necessary for reactor cooling systems. Furthermore, legal battles may also ensue over scarce water resources.

State Vulnerability Overview

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the State can range in severity from insignificant to a high degree of radioactive contamination within the two to 10-mile radius surrounding the facility. The most crucial concerns during a severe incident are safe evacuation and controlled access to the areas affected by a release of radioactive materials; these processes are managed under the State of Missouri Nuclear Power Plant Action Plan. In the aftermath of a radiological incident, the main concerns include the extent of property needing to be decontaminated, contaminated food sources, and the time required to reach acceptable exposure rates

and to allow the safe reentry of the public. Due to their safe operation records, fixed nuclear facilities have not historically represented a high risk to the State. The Reactor Safety Study conducted by the NRC rated the chances of a major nuclear disaster as very low (a probability of one in one million per plant operating year. This low hazard rating is due to all of the added safety engineered instrumentation used to monitor and shut down nuclear plant systems before any severe damage occurs.

An incident at a nuclear power plant resulting in a "general emergency" and evacuation (one where a release from the site boundary would be expected) could have a dramatic psychological impact on the uninformed population within the evacuation zone. The utilities and the State have an active Radiological Emergency Preparedness program to prepare local jurisdictions and the general population surrounding the plant for responding to such an incident. This program includes in-depth training of resources both from the State and local jurisdictions, and regularly scheduled drills and exercises evaluated by FEMA. Extensive planning has focused on implementation of the emergency response plan for both the State and local jurisdictions. Emphasis is placed on prompt notification of emergency organizations and the public; evacuation routes; reception and care centers for evacuees; monitoring for radiological contamination; emergency worker preparedness; and public information in the form of brochures distributed to residents within the emergency preparedness zone. These programs are essential to the protection of the general public.

Overview and Analysis of Vulnerability

An accident involving radioactive materials could occur in Missouri from a variety of sources: nuclear reactors, transportation accidents (see **Section 3.3.15** Hazardous Materials Incidents), industrial and medical uses, and lost or stolen sources where the public could be exposed, or contaminated, with a high level of radiation. Although the chance of a nuclear power plant release is unlikely, radiological accidents have the potential to cause injury or death, contaminate property and valuable environmental resources, as well as disrupt the functioning of communities and their economies.

Local and state governments, federal agencies, and the electric utilities have emergency response plans in place in the event of a nuclear power plant incident. The plans define two "emergency planning zones." One zone covers an area within a 10-mile radius of the plant, where it is possible that people could be harmed by direct radiation exposure. The second zone covers a broader area, usually up to a 50-mile radius from the plant, where radioactive materials could contaminate water supplies, food crops, and livestock.

The potential danger from an accident at a nuclear power plant is exposure to radiation. This exposure could come from the release of radioactive material from the plant into the environment, usually characterized by a plume (cloud-like formation) of radioactive gases and particles. The major hazards to people in the vicinity of the plume are radiation exposure to the body from the cloud and particles deposited on the ground, inhalation of radioactive materials, and ingestion of radioactive materials.

There are several Missouri counties included in 10-mile and 50-mile emergency planning zones (EPZ) for nuclear power plants. There are two commercial plants that could pose a threat to Missouri: The Callaway Nuclear Generating Station in Callaway County and the Cooper Nuclear Station in Nemaha County, Nebraska. There are also Missouri University of Science and Technology research reactors that support education, research, training, and regional industries.

Counties within the 10-mile EPZ for commercial nuclear power plants have a relatively higher radiological risk than other counties, but the potential for an incident is extremely low. These counties

include portions of Callaway, Osage, and Montgomery for the Callaway plant, and Atchison and Holt for the Cooper plant. Counties within the 50-mile ingestion pathway are at lower risk. For the Cooper plant, those counties include Andrew County and Nodaway County, in addition to those in the 10-mile EPZ. For the Callaway plant, counties within the 50-mile ingestion pathway include Audrain County, Boone County, Crawford County, Cole County, Cooper County, Franklin County, Gasconade County, Howard County, Lincoln County, Maries County, Miller County, Monroe County, Moniteau County, Pike County, Randolph County, Ralls County, St. Charles County, and Warren County.

State Estimates of Potential Losses

Table 3.83 below lists the counties within the 10-mile radius of the two nuclear power plants (Callaway and Cooper) that could impact Missouri in the event of an emergency or accident. This table provides counts and values of state-owned facilities as well as counts and rent value of state-leased facilities. It should be noted that this analysis considers all facilities that fall within counties that are wholly or partially in the radius zones.

Table 3.83. Counties within 10-mile radius

County	Total Facilities	Critical Facilities (Owned)	Critical Facilities (Rented)	Total Replacement Value	State-Leased Total Annual Rent
Callaway	91	41	-	$116,186,784	-
Montgomery	3	2	-	$124,962	-
Atchison	4	-	3	-	$34,328
Total	**98**	**43**	**3**	**$116,311,746**	**$34,328**

Hazard Impact on Future Growth and Development

None of the counties within the 10-mile EPZ for the Cooper or Callaway plants are in the top 10 counties for housing unit and population gains between 2010 and 2019. Boone and St. Charles Counties are within the 50-mile ingestion pathway for the Callaway plant and are among the top 10 counties for housing and population gains from 2010 to 2019.

Risk Summary

Nuclear reactors have been designed to survive natural disasters such as tornadoes and earthquakes without damage to critical systems. Considerable emphasis is placed on multiple-level governmental reviews of the design, construction, and operation of each nuclear power plant. These safety reviews begin prior to construction and continue throughout the operating life of the plant. Radiological planning and preparedness programs monitored by state and federal agencies are in place to ensure that emphasis is placed on the safety of the general public within the emergency planning zone. In addition, the historical record for nuclear power plants gives no indication that a serious accident involving a nuclear power plant will occur.

Problem Statement:

Using the Counties within a 10-mile radius of nuclear plants as the key indicator, the counties as most risk from fallout are Atchison, Callaway, Holt, Montgomery, and Osage. Mitigation strategies and limited resources would best be expended in these counties first.

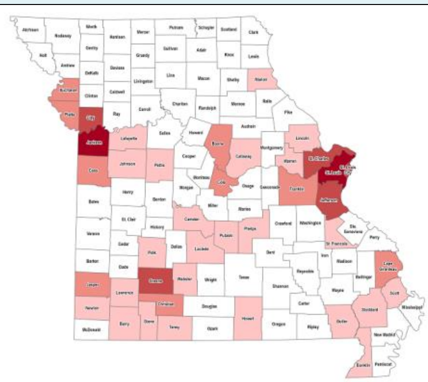
2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.18. Public Health Emergencies

Description

Public health emergencies can take many forms—disease epidemics, large-scale incidents of food or water contamination, or extended periods without adequate water and sewer services. There can also be harmful exposure to chemical, radiological, or biological agents, and largescale infestations of disease-carrying insects or rodents. Public health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people.

Vulnerability



Extent/Range of Intensity

Public health emergencies can be worldwide or localized in scope and magnitude. All of Missouri is at risk to public health emergencies. When on an epidemic scale, diseases can lead to high infection rates in the population causing isolation, quarantine, and potential mass fatalities. An especially severe influenza or coronavirus pandemic or other major disease outbreak can lead to high levels of illness, death, social disruption, and economic loss.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Buildings, infrastructure, and critical facilities are not vulnerable to this hazard – rather it affects only persons susceptible to the illness. Other lasting impacts and potential losses are largely economic and are dependent on the type, extent, and duration of the illness. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

Changing Future Conditions Considerations

Based on climate predictions, communities must contend with the human health impacts related to the increased prevalence of infectious diseases, heat waves, and changes in air and water quality. Heat stress is expected to increase as climate change brings hotter summer temperatures and more humidity. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Higher temperatures and wetter conditions tend to increase mosquito and tick activity, leading to an increased risk of zoonotic diseases. More frequent and extreme storm events can exacerbate the challenges communities face with sheltering, evacuation, and access to medical care and other resources during and after an extreme weather event.

Risk Summary/Problem Statement

Preparing for, responding to, and recovering from pandemic influenza, and other outbreaks will require a strategy with many similarities, be they naturally occurring or resulting from terrorist action. By its very nature, a pandemic, once started, will not be stopped until it has run its course. DHSS has emergency response plans in place, internally, and as part of the State response through the Missouri State Emergency Operations Plan (SEOP) that have been tried, tested and exercised for all aspects of response and recovery, including those mentioned above relating to disease surveillance, investigation and control.

Description/Location

Public health emergencies can take many forms—disease epidemics, large-scale incidents of food or water contamination, or extended periods without adequate water and sewer services. There can also be harmful exposure to chemical, radiological, or biological agents, and largescale infestations of disease-carrying insects or rodents. This section focuses on emerging public health concerns and potential pandemics, while the Environmental Health Section, **Section 3.3.14**, addresses natural and human-caused air and water pollution.

Public health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. For more information on those particular incidents, see **Sections 3.3.10** (Tornadoes/Severe Thunderstorms), **3.3.1** (Riverine Flooding), and **3.3.15** (Hazardous Materials Release). The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be worldwide or localized in scope and magnitude.

In particular, two public health hazards have recently emerged as issues of great concern, with far reaching consequences. One pertains to the intentional release of a radiological, chemical, or biological agent, as a terrorist act of sabotage to adversely impact a large number of people. For more information on biochemical terrorism, see **Section 3.3.20**. The second hazard concerns a deadly outbreak (other than one caused by an act of terrorism) that could kill or sicken thousands of people across the county or around the globe. The primary communicable, or infectious, disease addressed within this plan is influenza:

- **Influenza** - Whether natural or manmade, health officials say the threat of a dangerous new strain of influenza (flu) virus in pandemic proportions is a very real possibility in the years ahead. Unlike most illnesses, the flu is especially dangerous because it is spread through the air. A classic definition of influenza is a respiratory infection with fever. Each year, flu infects humans and spreads around the globe. There are four types of influenza virus: Types A, B, C, and D. Type A is the most common, most severe, and the primary cause of flu epidemics. Type B cases occur sporadically and sometimes as regional or widespread epidemics. Type C cases are quite rare and hence sporadic, but localized outbreaks have occurred. Influenza type D primarily affect cattle and are not known to infect or cause illness in people. Seasonal influenza usually is treatable, and the mortality rate remains low. Each year, scientists estimate which particular strain of flu is likely to spread, and they create a vaccine to combat it. A flu pandemic occurs when the virus suddenly changes or mutates and undergoes an —antigenic shift, permitting it to attach to a person‘s respiratory system and leave the body‘s immune system defenseless against the invader.
- **Coronaviruses** – Coronaviruses are a large family of viruses found in both animals and humans and are known to cause illness ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS), Severe Acute Respiratory Syndrome (SARS), and Novel Coronavirus (COVID- 19). Coronaviruses can cause respiratory infections and can lead to serious illnesses, like pneumonia, and can be deadly. Typical coronavirus symptoms include fever, cough, headache, runny nose, and sore throat. MERS was first reported in 2012 in Saudi Arabia and spread to more than 25 countries. It produced symptoms that often progressed to pneumonia and 30-40 percent of cases were fatal. SARS emerged in 2002 and spread to more than two dozen countries. It caused acute respiratory distress and had a mortality rate of about 10 percent.

The most significant recent coronavirus, COVID-19, first emerged in Wuhan, China in 2019 and rapidly spread across the world. According to CDC data, as of February 2022, there had been over 78.5 million cases of COVID-19 reported in the United States. COVID-19 spreads when an infected person breathes out droplets and very small particles that contain the virus. These droplets and particles can be breathed in by other people or land on their eyes, noses, or mouth. Symptoms include fever, cough, shortness of breath, fatigue, loss of taste and smell, and more. Symptoms range from mild to severe illness and typically appear between 2-14 days after exposure to the virus.

Additional diseases of public health concern include tuberculosis, Smallpox, St. Louis Encephalitis, Meningitis, Lyme disease, West Nile, Zika, and Ebola. These communicable diseases are introduced within this plan, but full vulnerability analyses are not included at this time.

- **Tuberculosis -** Tuberculosis, or TB, is the leading cause of infectious disease worldwide. It is caused by a bacteria called Mycobacterium tuberculosis that most often affects the lungs. TB is an airborne disease spread by coughing or sneezing from one person to another. The World Health Organization (WHO) estimates that one-third of the world's population, approximately two billion people, has latent TB, which means people have been infected by TB bacteria but are not yet ill with the disease and cannot transmit the disease. In 2020, 9.9 million people fell ill with TB and 1.3 million died from the disease (including 0.68 million among people with HIV). However, outside of 2015, the U.S. TB case count and incidence rate have declined every year since 1992, and the drop in 2020 was much steeper than previous years. Over 95% of TB deaths occur in low- and middle- income countries. In 2020, Missouri reported a total of 72 cases of TB disease.
- **Smallpox** - Smallpox is a contagious, sometimes fatal, infectious disease. There is no specific treatment for smallpox disease, and the only prevention is vaccination. Smallpox is caused by the variola virus that emerged in human populations thousands of years ago. It is generally spread by face- to-face contact or by direct contact with infected bodily fluids or contaminated objects (such as bedding or clothing). A person with smallpox is sometimes contagious with onset of fever, but the person becomes most contagious with the onset of rash. The rash typically develops into sores that spread over all parts of the body. The infected person remains contagious until the last smallpox scab is gone. Smallpox outbreaks have occurred periodically for thousands of years, but the disease is now largely eradicated after a worldwide vaccination program was implemented. After the disease was eliminated, routine vaccination among the general public was stopped. The last case of smallpox in the United States was in 1949.
- It should be noted that after recent terrorist events in the United States, there is heightened concern that the variola virus might be used as an agent of bioterrorism. For this reason, the U.S. government is taking precautions for dealing with a smallpox outbreak. For further information on this issue, see **Section 3.3.20** Terrorism.
- **St. Louis Encephalitis** - In the United States, the leading type of epidemic flaviviral Encephalitis is St. Louis encephalitis (SLE), which is transmitted by mosquitoes that become infected by feeding on birds infected with the virus. SLE is the most common mosquito-transmitted pathogen in the United States. There is no evidence to suggest that the virus can be spread from person to person. Most people infected with SLE virus do not have symptoms. Those people who do become ill may experience fever, headache, nausea, vomiting, and tiredness.
- **Meningitis**- Meningitis is an infection of fluid that surrounds a person‘s spinal cord and brain. High fever, headache, and stiff neck are common symptoms of meningitis, which can develop between

several hours to one to two days after exposure. Meningitis can be caused by either a viral or bacterial infection; however, a correct diagnosis is critically important, because treatments for the two varieties differ. Meningitis is transmitted through direct contact with respiratory secretions from an infected carrier. Primary risk groups include infants and young children, household contact with patients, and refugees. In the United States, periodic outbreaks continue to occur, particularly among adolescents and young adults. About 2,600 people in the United States get the disease each year. Generally, 10 to 14 percent of cases are fatal, and 11 to 19 percent of those who recover suffer from permanent hearing loss, mental retardation, loss of limbs, or other serious effects. Two vaccines are available in the United States.

- **Lyme Disease** - Lyme disease was named after the town of Lyme, Connecticut, where an unusually large frequency of arthritis-like symptoms was observed in children in 1977. It was later found that the problem was caused by bacteria transmitted to humans by infected deer ticks, causing an average of more than 16,000 reported infections in the United States each year (however, the disease is greatly under-reported). Lyme disease bacteria are not transmitted from person to person. Following a tick bite, 80 percent of patients develop a red bulls-eye rash accompanied by tiredness, fever, headache, stiff neck, muscle aches, and joint pain. If untreated, some patients may develop arthritis, neurological abnormalities, and cardiac problems, weeks to months later. Lyme disease is rarely fatal. During early stages of the disease, oral antibiotic treatment is generally effective, while intravenous treatment may be required in more severe cases.
- **West Nile Virus** - West Nile virus is a flavivirus spread by infected mosquitoes and is commonly found in Africa, West Asia, and the Middle East. It was first documented in the United States in 1999. Although it is not known where the U.S. virus originated, it most closely resembles strains found in the Middle East. It is closely related to St. Louis encephalitis and can infect humans, birds, mosquitoes, horses, and other mammals.
- Most people who become infected with West Nile virus will have either no symptoms or only mild effects. However, on rare occasions, the infection can result in severe and sometimes fatal illness. There is no evidence to suggest that the virus can be spread from person to person.
- An abundance of dead birds in an area may indicate that West Nile virus is circulating between the birds and mosquitoes in that area. Although birds are particularly susceptible to the virus, most infected birds survive. The continued expansion of West Nile virus in the United States indicates that it is permanently established in the Western Hemisphere.
- **Zika Virus** - Discovered in the Zika forest of Uganda in 1947, the Zika virus is a member of the flavivirus family. It is transmitted to humans through the bite of an infected Aedes species mosquito (Ae. aegypti and Ae. albopictus). Zika virus can also be transmitted from an infected pregnant woman to her baby during pregnancy and can result in serious birth defects, including microcephaly. Less commonly, the virus can be spread through intercourse or blood transfusion. However, most people infected with the Zika virus do not become sick.
- **Ebola –** Previously known as Ebola hemorrhagic fever, is a rare and deadly disease caused by infection with one of the Ebola virus species. It was first discovered in 1976 near the Ebola River in what is now the Democratic Republic of the Congo. Since then, outbreaks have appeared sporadically in Africa.

Extent /Range of Intensity

All of Missouri is at risk to public health emergencies. When on an epidemic scale, diseases can lead to high infection rates in the population causing isolation, quarantine, and potential mass fatalities. An especially severe influenza or coronavirus pandemic or other major disease outbreak can lead to high levels of illness, death, social disruption, and economic loss. As was seen during the COVID-19 pandemic, impacts can range from school and business closings to the interruption of basic services such as public transportation, health care, and the delivery of food and essential medicines.

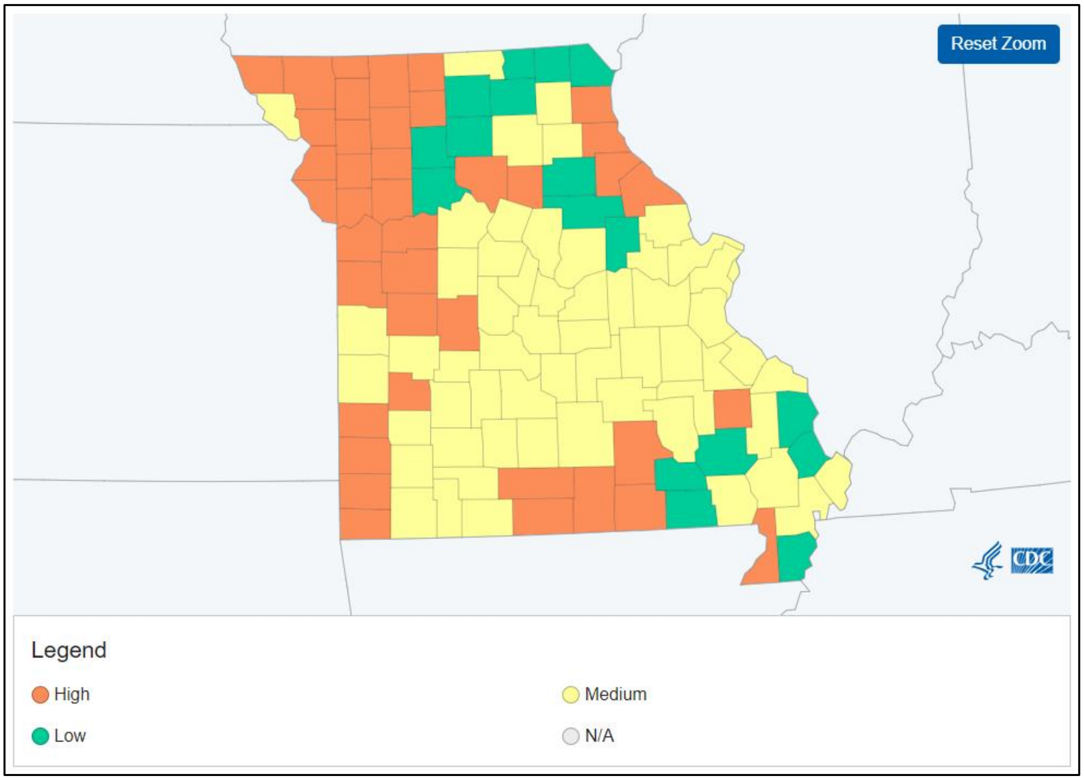
The Missouri Department of Health and Senior Services (DHSS) tracks the spread of influenza and other communicable diseases within the State through reporting from hospitals, laboratories, and healthcare providers. Reporting can be based on a positive laboratory test, clinical symptoms, or epidemiologic criteria. A public health investigation may also be conducted to determine and implement appropriate public health interventions.

Specific Information regarding the current situation as of February 2022 with COVID-19 in Missouri are included in **Figure 3.163**. As of late February 2022, there have been over 1.1 million confirmed COVID-19 cases and 15,402 confirmed deaths in Missouri. The virus has had widespread impacts on the entire state, however, the counties with the highest number of reported cases are St Louis, Kansas City, St Charles Greene, and Jackson. The CDC uses a tool to monitor COVID-19 Community Levels. Each county's COVID-19 Community Level is ranked as low, medium, or high. The COVID-19 Community Levels are classified as follows:

- *Low* – Limited impact on healthcare system, low levels of severe illness
- *Medium* – Some impact on healthcare system, more people with severe illness
- *High* – High potential for health system strain, high level of severe illness

The levels are determined by a combination of how many people with COVID-19 have been admitted into local hospitals in the last week; how many local hospital beds are filled with COVID-19 patients; and how many new COVID-19 cases the county has had in the last week.

Figure 3.163. Missouri COVID – 19 Community Level Rating, 2022



Source: CDC, February 24, 2022 - https://www.cdc.gov/coronavirus/2019-ncov/your-health/covid-by-county.html

The Missouri DHSS is monitoring the COVID-19 outbreak by reporting confirmed and suspected cases and conducting more frequent analysis of data. The department also provides up to date information on vaccination and testing resources, and other useful information for local public health agencies and the medical community on ways to deal with pandemic outbreak. DHSS also works closely with the news media to disseminate information about the virus. The DHSS website for COVID – 19 information, reporting, and data is available here: https://health.mo.gov/living/healthcondiseases/communicable/novel-coronavirus/

DHSS prepared a Missouri Pandemic Influenza Response plan to help communities manage and prepare for pandemic flu outbreaks. The Pandemic Influenza Response Plan is available here: https://health.mo.gov/emergencies/readyin3/pdf/PanFluCommunityGuide.pdf

Figure 3.163 describes the World Health Organization's (WHO) six main phases to a pandemic flu as part of their planning guidance.

Table 3.84. World Health Organization's Pandemic Flu Phases

Phase	Description
1	No animal influenza virus circulating among animals have been reported to cause infection in humans.
2	An animal influenza virus circulating in domesticated or wild animals is known to have caused infection in humans and is therefore considered a specific potential pandemic threat.

Phase	Description
3	An animal or human-animal influenza reassortment virus has caused sporadic cases or small clusters of disease in people but has not resulted in human-to-human transmission sufficient to sustain community-level breakouts.
4	Human-to-human transmission of an animal or human-animal influenza reassortment virus able to sustain community-level breakouts has been verified.
5	The same identified virus has caused sustained community level outbreaks in two or more counties in one WHO region.
6	In addition to the criteria defined in Phase 5, the same virus has caused sustained community level outbreaks in at least one other county in another WHO region.
Post – Peak Period	Levels of pandemic influence in most countries with adequate surveillance have dropped below peak levels.
Post – Pandemic Period	Levels of influence activity have returned to the levels seen for seasonal influenza in most countries with adequate surveillance.

Source: WHO: https://www.ncbi.nlm.nih.gov/books/NBK143061/

Previous Occurrences

Public Health Emergencies - Pandemics

Since the early 1900s, five lethal pandemics have swept the globe: Spanish Flu of 1918-1919; Asian Flu of 1957-1958; Hong Kong Flu of 1968-1969; Swine Flu of 2009-2010; and COVID-19 of 2019 to present. The Spanish Flu was the most severe pandemic in recent history. The number of deaths was estimated to be 50-100 million worldwide and 675,000 in the United States. Its primary victims were mostly young, healthy adults. The 1957 Asian Flu pandemic killed about 70,000 people in the United States, mostly the elderly and chronically ill. The 1968 Hong Kong Flu pandemic killed 34,000 Americans. The 2009 Swine Flu caused 12,469 deaths in the United States. As of March 2022, the COVID – 19 pandemic has caused over 947,000 deaths in the U.S. and over 5.9 million death globally. These pandemics are further defined in the following paragraphs along with several “pandemic scares”.

Spanish Flu (H1N1 virus) of 1918-1919

In 1918, when World War I was in its fourth year, another threat began that rivaled the war itself as the greatest killer in human history. The Spanish Flu swept the world in three waves during a two-year period, beginning in March 1918 with a relatively mild assault.

The first reported case occurred at Camp Funston (Fort Riley), Kansas, where 60,000 soldiers trained to be deployed overseas. Within four months, the virus traversed the globe, as American soldiers brought the virus to Europe. The first wave sickened thousands of people and caused many deaths (46 died at Camp Funston), but it was considered mild compared to what was to come. The second and deadliest wave struck in the autumn of 1918 and killed millions. At Camp Funston alone, there were 14,000 cases and 861 deaths reported during the first three weeks of October 1918.

Outbreaks caused by a new variant exploded almost simultaneously in many locations including France, Sierra Leone, Boston, and New York City, where more than 20,000 people died that fall. The flu gained its name from Spain, which was one of the hardest hit countries. From there, the flu went through the Middle East and around the world, eventually returning to the United States along with the troops.

Of the 57,000 Americans who died in World War I, 43,000 died as a result of the Spanish Flu. At one point, more than 10 percent of the American workforce was bedridden. By a conservative estimate, a

fifth of the human race suffered the fever and aches of influenza between 1918 and 1919 and 20 million people died.

In 1918, Missouri‘s influenza death rate was 293.83 per 100,000 people, for a total of 9,677 deaths statewide from that cause alone. That figure represents 18.6 percent of Missouri‘s total deaths that year. While the cause of the Spanish Flu remains somewhat a mystery, the epidemic was generally traced to pigs on Midwest farms, which then spread the deadly virus to arm families. As fall crops were ready for harvest in 1918, there were no field hands to get the crops in, thereby creating an agricultural disaster, as well.

A third wave of the Spanish Flu, much less devastating than its predecessors, made its way through the world in early 1919 and then died out. Missouri‘s flu death rate in 1919 dropped to less than half that of the previous year (107.21 per 100,000), and by 1921, it was reduced to 87.24 deaths per 100,000 people, state statistics show.

Asian Flu (H2N2 virus) of 1957-1958

This influenza pandemic was first identified in February 1957 in the Far East. Unlike the Spanish Flu, the 1957 virus was quickly identified, and vaccine production began in May 1957. A number of small outbreaks occurred in the United States during the summer of 1957, with infection rates highest among school children, young adults, and pregnant women; however, the elderly had the highest rates of death. A second wave of infections occurred early the following year, which is typical of many pandemics.

Hong Kong Flu (H3N2 virus) of 1968-1969

This influenza pandemic was first detected in early 1968 in Hong Kong. The first cases in the United States were detected in September 1968, although widespread illness did not occur until December. This became the mildest pandemic of the twentieth century, with those over the age of 65 the most likely to die. People infected earlier by the Asian Flu virus may have developed some immunity against the Hong Kong Flu virus. Also, this pandemic peaked during school holidays in December, limiting student-related infections.

Pandemic Flu Threats: Swine Flu of 1976, Russian Flu of 1977, and Avian Flu of 1997 and 1999

Three notable flu scares occurred in the twentieth century. In 1976, a swine-type influenza virus appeared in a U.S. military barracks (Fort Dix, New Jersey). Scientists determined it was an antigenically drifted variant of the feared 1918 virus. Fortunately, a pandemic never materialized, although the news media made a significant argument about the need for a Swine Flu vaccine.

In May 1977, influenza viruses in northern China spread rapidly and caused epidemic disease in children and young adults. By January 1978, the virus, subsequently known as the Russian Flu, had spread around the world, including the United States. A vaccine was developed for the virus for the 1978–1979 flu season. Because illness occurred primarily in children, this was not considered a true pandemic.

In March 1997, scores of chickens in Hong Kong‘s rural New Territories began to die—6,800 on three farms alone. The Avian Flu virus was especially virulent, and made an unusual jump from chickens to humans. At least 18 people were infected, and six died in the outbreak. Chinese authorities acted quickly to exterminate over one million chickens and successfully prevented further spread of the disease. In 1999, a new avian flu virus appeared. The new virus caused illness in two children in Hong Kong. Neither of these avian flu viruses started pandemics.

Swine Flu (H1N1 virus) of 2009–2010

This influenza pandemic emerged from Mexico in 2009. The first U.S. case of H1N1, or Swine Flu, was diagnosed on April 15, 2009. The U.S. government declared H1N1 a public health emergency on April 26. By June, approximately 18,000 cases of H1N1 had been reported in the United States. A total of 74 countries were affected by the pandemic.

The CDC estimates that 43 million to 89 million people were infected with H1N1 between April 2009 and April 2010. There were an estimated 8,870 to 18,300 H1N1 related deaths. On August 10, 2010, the World Health Organization (WHO) declared an end to the global H1N1 flu pandemic.

Coronavirus Disease (COVID-19) of 2019 – ongoing

During the update of this plan, COVID-19 has been an ongoing pandemic. COVID-19 was caused by severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2). First identified in Wuhan, China in December 2019, the virus quickly spread throughout China and then globally. In the United States, COVID-19 was first identified in late January in Washington State and rapidly spread throughout the Country, with large epicenters on both the east and west coasts. On March 13, 2020 the U.S. enters a nationwide emergency and by March 15, 2020 U.S. states begin to shut down to prevent the spread of COVID-19. Almost a year later the U.S. has administered over 100 million vaccinations. In June 2021 the first major variant, the Delta variant, becomes dominant in the U.S. which kicks off a third wave of infections during the summer of 2021. By December 20, 2021, Omicron, the second and most dominant variant in the U.S., had been detected in most U.S. states and territories. The Omicron variant spread more easily than the original virus that caused COVID-19 and the Delta variant.

As of March 2, 2022, according to the World Health Organization, there were over 437 million cases worldwide resulting in over 5.9 million deaths. The United States has accounted for over 78.3 million cases and an estimated 943,293 deaths. In the State of Missouri, there have been over 1.1 million cases and 15,413 deaths due to COVID-19.

Additional Public Health Emergencies

St. Louis Encephalitis, 1964-2005

Between 1964 and 2005, there were 4,651 confirmed cases of SLE in the United States. Seventy-five of these cases were in Missouri. According to the U.S. Geological Survey, there was one case of SLE in Missouri in 2006. It should be noted, however, that less than 1 percent of SLE infections are clinically apparent, so the vast majority of infections remain undiagnosed. Illnesses range from mild headaches and fever to convulsions, coma, and paralysis. The last major outbreak of SLE occurred in the Midwest from 1974 to 1977, when over 2,500 cases were reported in 35 states. The most recent outbreak of St. Louis encephalitis was in 1999 in New Orleans, Louisiana, with 20 reported cases. The disease is generally milder in children than in adults, with the elderly at highest risk for severe illness and death. Approximately 3 to 30 percent of cases are fatal; no vaccine against SLE exists. In 2011, one probable case was reported in Boone County, MO.

Meningitis, 1996-1997, 2005

During 1996 and 1997, 213,658 cases of meningitis were reported, with 21,830 deaths, in Africa. According to the Missouri Department of Health and Senior Services, there were 28 cases in Missouri in 2005.

Lyme Disease, 2015

In the United States, Lyme disease is mostly found in the northeastern, mid-Atlantic, and upper north-central regions, and in several counties in northwestern California. In 2019, 93-percent of confirmed Lyme Disease cases were reported from 14 states: Connecticut, Delaware, Maine, Maryland, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin. Lyme disease is the most common vector-borne disease in the United States. According to the CDC, recent estimates based on insurance records suggest that approximately 476,000 Americans are diagnosed and treated with Lyme disease each year. This disease does **not** occur nationwide and is concentrated heavily in the northeast and upper Midwest. In 2019 Missouri had 2 confirmed cases of Lyme disease.

Severe Acute Respiratory Syndrome, 2003

During November 2002-July 2003, a total of 8,098 probable SARS cases were reported to the World Health Organization (WHO) from 29 countries. In the United States, only 8 cases had laboratory evidence of infection. There were no confirmed cases in Missouri. Since July 2003, when SARS transmission was declared contained, active global surveillance for SARS disease has detected no person-to-person transmission. CDC has therefore archived the case report summaries for the 2003 outbreak.

Zika Virus, 2015

In May 2015, the Pan American Health Organization issued an alert noting the first confirmed case of a Zika virus infection in Brazil. Since that time, Brazil and other Central and South America countries and territories, as well as the Caribbean, Puerto Rico, and the U.S. Virgin Islands have experienced ongoing Zika virus transmission. In August 2016, the Centers for Disease Control and Prevention (CDC) issued guidance for people living in or traveling to a 1-square-mile area Miami, Florida, identified by the Florida

Department of Health as having mosquito-borne spread of Zika. In October 2016, the transmission area was expanded to include a 4.5-square-mile area of Miami Beach and a 1-squre mile area of Miami-Dade County. In addition, all of Miami-Dade County was identified as a cautionary area with an unspecified level of risk. In Missouri, there have been 32 confirmed travel-associated cases of Zika virus, but no locally acquired cases.

As of February 2022, there are no current local transmission of Zika virus in the continental U.S. or territories. The last cases of local Zika transmission by mosquitos in the continental U.S. were in Florida and Texas in 2016-17 and no reported cases from U.S. territories since 2019.

Ebola, 2014-2016

In March 2014, West Africa experienced the largest outbreak of Ebola in history. Widespread transmission was found in Liberia, Sierra Leone, and Guinea with the number of cases totaling 28,616 and the number of deaths totaling 11,310. In the United States, four cases of Ebola were confirmed in 2014 including a medical aid worker returning to New York from Guinea, two healthcare workers at Texas Presbyterian Hospital who provided care for a diagnosed patient, and the diagnosed patient who traveled to Dallas, Texas from Liberia. All three healthcare workers recovered. The diagnosed patient passed away in October 2014.

In March 2016, the WHO terminated the public health emergency for the Ebola outbreak in West Africa.

Probability of Future Hazard Events

It is impossible to predict when the next pandemic will occur or its impact, thus noted as <1-percent. The CDC continually monitors and assesses pandemic threats and prepares for an influenza pandemic and other outbreaks. Because the CDC cannot predict how severe a future pandemic will be, advance planning is needed at the national, state and local level.

Today, a much larger percentage of the world's population is clustered in cities, making them ideal breeding grounds for epidemics. Additionally, the explosive growth in air travel means the virus could literally be spread around the globe within hours. Under such conditions, there may be very little warning time. Most experts believe we will have just one to six months between the time that a dangerous new influenza strain is identified and the time that outbreaks begin to occur in the United States. Outbreaks are expected to occur simultaneously throughout much of the nation, preventing shifts in human and material resources that normally occur with other natural disasters. These and many other aspects make influenza pandemic unlike any other public health emergency or community disaster.

Changing Future Conditions Considerations

According to the U.S. Global Change Research Program, the influences of climate change on public health is significant and varied. The influences range from the clear threats of temperature extremes and severe storms to less obvious connections related to insects. Climate and weather can also affect water and food quality in particular areas, with implications for public health.

Hot days can be unhealthy—even dangerous. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Midwestern cities like St. Louis are vulnerable to heat waves, because many houses and apartments lack air conditioning, and urban areas are typically warmer than their rural surroundings. In recent decades, severe heat waves have

killed hundreds of people across the Midwest. Heat stress is expected to increase as climate change brings hotter summer temperatures and more humidity. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

Higher temperatures and wetter conditions tend to increase mosquito and tick activity, leading to an increased risk of zoonotic diseases. Mosquitos are known to carry diseases such as West Nile virus (WNV), La Crosse/California encephalitis, Jamestown Canyon virus, St. Louis encephalitis, and Eastern equine encephalitis. The two major concerns associated with warmer and wetter conditions are that the mosquito species already found in Missouri and the diseases that they carry will become more prevalent, and that new species carrying unfamiliar diseases will start to appear for the first time.

Warmer winters with fewer hard freezes in areas that already see WNV-carrying mosquitos are likely to observe both a higher incidence of WNV and a longer WNV season, ultimately leading to an increase in human cases. Non-native mosquito species may move into Missouri if the climate becomes more suitable for them, bringing with them diseases such as Jamestown Canyon virus, Chikungunya, and Dengue Fever.

Ticks are also well-known disease vectors in Missouri, carrying pathogens such as Lyme disease, anaplasmosis, Ehrlichiosis, Powassan virus, and Babesiosis. With changing climate conditions, ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.

The COVID – 19 pandemic has highlighted the challenges experienced when trying to prepare and plan for extreme weather event, like a hurricane or other natural hazards, during a global pandemic. More frequent and extreme storm events can exacerbate the challenges communities face with sheltering, evacuation, and access to medical care and other resources during and after an extreme weather event.

If these predictions come true, communities must contend with the human health impacts related to the increased prevalence of infectious diseases, heat waves, and changes in air and water quality. Public health officials will need to focus on spreading information and enacting pest and disease reduction. Flood prone communities will need to focus on continuously improving flood controls and mitigation strategies.

A report by Trust for America's Health "Climate Change & Health" examines the readiness of each state to protect residents from the health impacts of climate change in light of the nature and level of risks that they face. A set of quantitative indicators were developed to assess each state and the District of Columbia, drawing from three domains of inquiry: (1) vulnerability; (2) public health preparedness; and (3) climate-related adaptation. Missouri is more vulnerable than most to the health impacts of climate change, and moderately prepared for the public health consequences. This report is included in Appendix E.

State Vulnerability Overview

For planning purposes, it is reasonable to assume a rapid movement of a pandemic flu virus, or another disease outbreak, from major metropolitan areas to rural areas of the State. The effect of an influenza pandemic on individual communities would likely be relatively prolonged—weeks to months. However, the COVID-19 pandemic has spanned years.

According to the Trust for America's Health, a non-profit organization dedicated to making disease prevention a national priority, "*Missouri's public health outcomes generally lag those of the United*

States, and it has not taken several steps that would strengthen its preparedness for public health emergencies." In a 2021 report done by the organization, Missouri was ranked a low tier state in terms of ten top-priority indicators of state public health preparedness. **Table 3.85** displays the ten indicators and **Table 3.86** shows Missouri's results.

Table 3.85. Top-priority Indicators of State Public Health Preparedness

Indicators			
1	**Incident Management:** Adoption of the Nurse Licensure Compact.	**6**	**Water Security:** Percentage of the population that used a community water system that failed to meet all applicable health-based standards.
2	**Cross-Sector Community Collaboration:** Percentage of hospitals participating in healthcare coalitions.	**7**	**Workforce Resiliency and Infection Control:** Percentage of employed population that used paid time off.
3	**Institutional Quality:** Accreditation by the Public Health Accreditation Board.	**8**	**Countermeasure Utilization:** Percentage of people ages 6 months or older who received a seasonal flu vaccination.
4	**Institutional Quality:** Accreditation by the Emergency Management Accreditation Program	**9**	**Patient Safety:** Percentage of hospitals with a top-quality ranking ("A" grade) on the Leapfrog Hospital Safety Grade
5	**Public Health Funding:** Size of the state public health budget compared with the past year.	**10**	**Health Security Surveillance**: The public health laboratory has a plan for a six- to eight-week surge in testing capacity

Source: Trust for America's Health, *Ready or Not: Protecting the Public's Health from Diseases, Disasters, and Bioterrorism, 2021*: https://www.tfah.org/wp-content/uploads/2021/03/TFAH_ReadyOrNot2021_Fnl.pdf

Table 3.86. Missouri's Rank among the Top-priority Indicators of State Public Health Preparedness

Indicators	Missouri
Nurse Licensure Compact *State participates in NLC, 2020*	X
Hospital Preparedness Program *% hospitals participating in health care coalitions, 2017*	87%
Public Health Accreditation Board *Accredited by PHAB, 2020*	X
Emergency Management Accreditation Program *Accredited by EMAP, 2020*	X
Public Health Funding *% change, FY 2019-20*	-1%
Water Security *% of population who used a community water system in violation of health – based standards, 2019*	9%
Paid Time Off *% of employed population who used paid time off, 2019*	53%
Seasonal Flu Vaccination *Seasonal flu vaccination rate for people ages 6 months or older, 2019–20*	50.2
Patient Safety *% of hospitals with "A" grade, fall 2020*	24%
Public Health Lab Capacity *Public health laboratories had a plan for a six- to eight-week surge in testing capacity, 2020*	X
State Performance *Scoring tier, 2020*	**Low**

Source: Trust for America's Health, *Ready or Not: Protecting the Public's Health from Diseases, Disasters, and Bioterrorism, 2021*: https://www.tfah.org/wp-content/uploads/2021/03/TFAH_ReadyOrNot2021_Fnl.pdf

The impact of the COVID-19 pandemic has had a devastating effect on the health and well-being of Missouri citizens and the American public. Below are COVID-19 estimates from the CDC for February 2020 to September 2021. These estimates better reflect the full burden of COVID-19 and adjust for cases that national surveillance networks do not capture for a number of reasons. These estimates are likely higher as a highly contagious variant, Omicron, became dominant in the U.S. by December 2021.

- Over 146 million total infections
- 124 million persons with symptomatic illness
- Over 7 million hospitalizations
- Over 947,882 deaths nationwide*
- Effective preventive and therapeutic measures, including vaccines, and protective face coverings were in short supply, during the early stages of the pandemic.

*Number of deaths as of March 1, 2022

As previously noted, all of Missouri is at risk to public health emergencies. There are a few special populations that are at increased risk for infectious diseases. Those special populations include: the institutionalized elderly, prison populations, and children, especially un-immunized children (for vaccine preventable diseases). Special populations in Missouri have been estimated as follows:

- The Missouri DHSS reports that in February 2022 there were a total of 1,171 licensed adult care homes in Missouri with a census of 54,233 persons. The total available licensed adult care home beds for the State was 84,017.
    - https://health.mo.gov/seniors/nursinghomes/pdf/BEDCENSUS.pdf
- The Missouri Department of Corrections indicates 23,000 incarcerated offenders as of March, 2022. The Department of Corrections 2016 Annual Report (most recent) reports that 3,676 individuals are over the age of 55 years.
    - https://doc.mo.gov/sites/doc/files/2018-01/AR2016.pdf
- The Missouri Department of Elementary and Secondary Education 2010-2021 statistics of Missouri Public Schools indicates that 859,396 children are enrolled in elementary and secondary education institutions.
    - https://apps.dese.mo.gov/MCDS/Visualizations.aspx?id=22
      https://apps.dese.mo.gov/MCDS/home.aspx?categoryid=2&view=2

Vaccine preventable diseases are rare, but they do occur. The consequences of vaccine preventable childhood diseases can be quite serious and include liver damage, hearing loss, blindness, coma, and death. Childhood immunization rates are relatively high for Missouri yet approximately 4 to 29 percent are not adequately immunized against certain diseases. Childhood immunizations are safe with only minimal side effects of pain, redness and swelling at the injection site, compared to the horrible consequences of the diseases themselves. The CDC's National Center for Immunization and Respiratory Diseases (NCIRD) data showed that Missouri is relatively close to the nation in select vaccination coverages for school year 2019-2020. Data from SchoolVaxView is displayed in **Table 3.87**.

Table 3.87. Estimated Vaccination Coverage Among Kindergartners (N = 72,324), 2019 - 2020

	DTP/DTaP/DT	HepB	MMR	1 Dose Varicella	2 Dose Varicella	Polio
United States	94.9	96.1	95.2	94.1	94.8	95.0
Missouri	94.5	95.9	94.6	-	94.2	94.9

Source: National Center for Immunization and Respiratory Diseases, United States, School Year 2019-2020; Data available on SchoolVaxView: https://www.cdc.gov/vaccines/imz-managers/coverage/schoolvaxview/index.html

State Estimates of Potential Losses

For this State Hazard Mitigation Plan Update, pandemic influenza was used to estimate potential losses from a public health emergency. The Missouri Department of Health and Senior Service's Pandemic Influenza Response Plan, for planning purposes, assumes the up to 30 percent of the general population could become ill with influenza. Combining this assumption with an estimate of age distribution for influenza cases and the estimated direct and indirect health care costs, the economic impact of pandemic influenza can be calculated for each county within Missouri. **Table 3.88** below presents the estimates for age distribution and disease outcome.

Table 3.88. Estimate of Age Distribution of Cases and Percentage of Hospitalizations

Age Group	Age Distribution of Cases[1]		Distribution of Disease Outcomes for 1918-type Pandemic Rates per 1,000 Persons[2]		Economic Impact[1]
	Percentage of All Cases	Percentage of High Risk Cases	Hospitalizations NOT at High Risk	Hospitalizations AT High Risk	Hospitalization Costs (in 2021 US$)
0-19	40.0	6.4	4.110	23.838	$5,333
20-64	53.1	14.4	12.042	24.578	$10,927
65+	6.8	40.0	18.495	69.871	$12,453

Source: [1]The Economic Impact of Pandemic Influenza in the United States: Priorities for Intervention; Martin I. Meltzer, Nancy J. Cox, and Keiji Fukuda; https://www.ncbi.nlm.nih.gov/pubmed/10511522; and
[2]CDC Flu Surge Model; https://www.cdc.gov/flu/pandemic-resources/tools/downloads/pandemic-impact-estimate-instructions.pdf

Rankings of vulnerability were assigned based on potential hospital charges and grouped according to natural breaks in the data:

- Low: $74,959- $955,924
- Low-medium: $955,925- $2,496,873
- Medium: $2,496,874 - $6,731,852
- Medium-High: $6,731,853- $14,927,071
- High: $14,927,072- $37,317,640

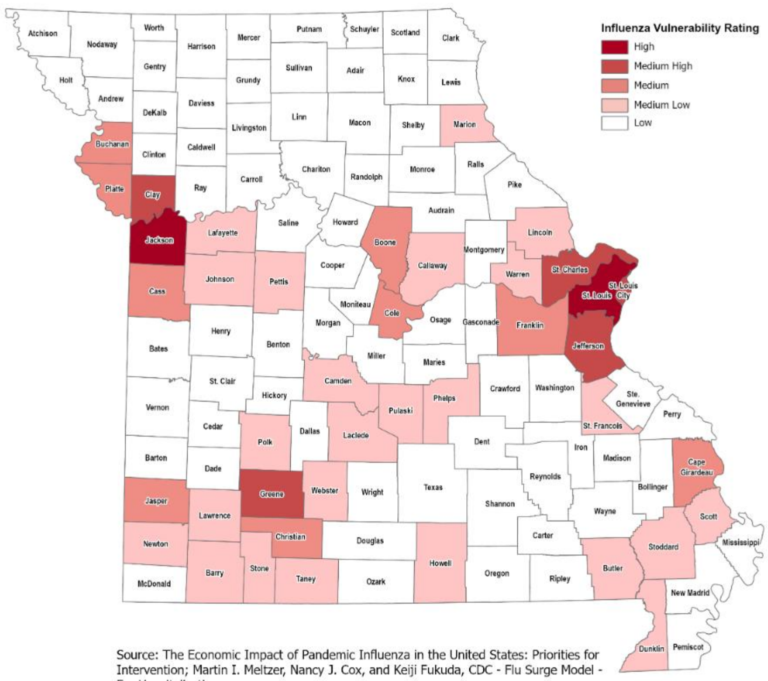
All county-level statistical data tables, including ranges for vulnerability factor ratings, are presented in Appendix A. **Figure 3.164** portrays this analysis in a statewide map.

Other lasting impacts and potential losses are largely economic and are dependent on the type, extent, and duration of the illness. A 2007 study prepared by the Trust for America's Health, developed a model to assess the potential impact of a pandemic flu on each states' workforce and how 20 key industry sectors and trade would be affected. Economic impact to Missouri was estimated to include the following:

- Projected GDP Loss from Pandemic: $12.4 billion
- Projected GDP Percentage Loss from Pandemic: 5.74%
- Ranking of Percentage Losses Out of 50 States (Highest = 1): 14
- Projected Impact on the Workforce: $5.5 billion in losses
- Projected Impact on Industries: $4.7 billion in losses
- Projected Trade Impact: $2.2 billion in losses
- Projected Number of Lives Lost: 47,000

- Projected Number of Sick Workers (assuming 3 weeks of work lost (with 50 weeks of work per year) from those who are either ill, fear the risk of infection at work, or need to take care of sick family members): 1,717,000

Figure 3.164. Potential Vulnerability of Missouri Counties to Pandemic Influenza



Source: The Economic Impact of Pandemic Influenza in the United States: Priorities for Intervention; Martin I. Meltzer, Nancy J. Cox, and Keiji Fukuda, CDC - Flu Surge Model - For Hospitalizations

Hazard Impact on Future Growth and Development

As populations increase and the cost of health care climbs, potential losses can be expected to rise. In the United States, in 2020, the proportion of people out of work hit a yearly total of 8.9%, according to the International Monetary Fund (IMF), signaling an end to a decade of jobs expansion. Another pandemic similar in scale to the COVID-19 outbreak could have significant economic consequences. Pew Research center estimates that roughly 9.6 million U.S. workers lost their jobs between 2019 and 2020. Millions of workers were put on government-supported job retention schemes as parts of the economy, such as tourism and hospitality, came to a near standstill.

Risk Summary

Preparing for, responding to, and recovering from pandemic influenza, and other outbreaks will require a strategy with many similarities, be they naturally occurring or resulting from terrorist action. The time-honored public health activities to lessen the impact on morbidity and mortality such as education, vaccination, prophylaxis, isolation/quarantine, and the closure of public facilities are common to all, despite the particular disease of concern. In addition, clear, concise communication with the public, within the Missouri Department of Health and Senior Services (DHSS), and with other agencies remains a critical component, as does the ability of the involved agencies to achieve collaboration and coordination. By its very nature, a pandemic, once started, will not be stopped until it has run its course. This course can be shortened and weakened by many things, with vaccination being the gold standard

for protecting the population. Pandemic plans describe strategies of preparedness, response, and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., that do not overwhelm the critical infrastructures of the State), and to promote community resiliency and rapid recovery.

DHSS has emergency response plans in place, internally, and as part of the State response through the Missouri State Emergency Operations Plan (SEOP) that have been tried, tested and exercised for all aspects of response and recovery, including those mentioned above relating to disease surveillance, investigation and control. Where necessary, details or public information templates unique to the pandemic have been added into plans. The current 2020 Pandemic Influenza Response Plan gives background information related to pandemic influenza, outlines the DHSS concept of operations for response, lists primary and support functional areas and provides technical support annexes outlining the available resources (i.e., "tools") available to temper the pandemic and promote community resiliency and recovery. Components of other all-hazard plans incorporated through partnership with the State Emergency Management Agency and other local, state, and federal agencies are expected to be utilized in accordance with need.

A broad, diverse and geographically dispersed group of agencies and organizations, representing the length, breadth and interests of the State collaborated with the DHSS in working to prepare for pandemic influenza. With committees organized under the umbrella of the Missouri Homeland Security Council, over four hundred representatives from hospitals, livestock corporations, local public health agencies (LPHAs), other state agencies, funeral homes, laboratories, financial institutions, fire departments, local and state governments, school boards, utility companies, universities, nursing homes and coroner's offices, among others, engaged with DHSS providing input and expertise to produce a meaningful plan.

DHSS has primary responsibility to safeguard the health of the people of the State and all its subdivisions and will respond in the event of pandemic influenza to attempt to limit the impact on public health by reducing morbidity and mortality. These actions may also limit the impact on the social and economic infrastructure of the State. DHSS will serve to support the LPHAs in this effort and lead the State-level response of a coordinated multitude of federal, state and private organizations and agencies. DHSS reserves the flexibility to modify the plan during the pandemic in response to the actual behavior of the disease and the effectiveness of the ongoing response. Lessons learned from previous waves will be incorporated going forward and modifications in planning may be made across all sectors to meet the key goals in public health and critical infrastructure support. Such changes will be rapidly and effectively communicated from DHSS to all partnered agencies and organizations per the communications plan to ensure best practices are consistently implemented statewide.

Problem Statement:

Using population and major transportation corridors as key indicators, the data suggests that counties at most risk are Boone, Christian, Clay, Franklin, Greene, Jackson, Jasper, Jefferson, St. Charles, St. Louis, and St. Louis City. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

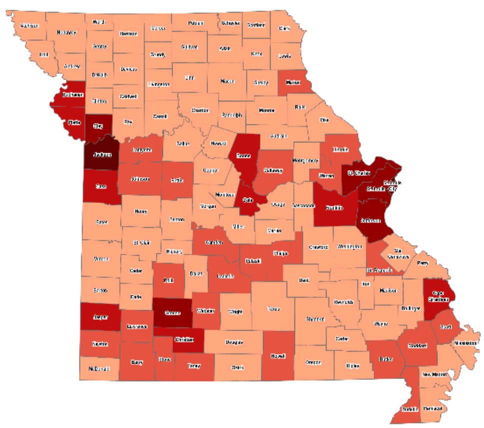
2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023

3.3.19. Special Events

Description

Special events present a unique set of challenges and security issues, including vulnerability to both man-made and natural hazards. Special events can include sporting events, concerts, political events, and events with religious significance, and can be handled at the local, state or federal level, depending on the size and scope of the event itself. Security for some special events can be handled with local- and state-level coordination, while some events rise to a level of national significance requiring a National Special Security Event designation and federal agency input and direction. Special events usually occur in larger cities, though this isn't always the case. When planning for special events, security officials should account for vulnerability to both natural and man-made hazards.

Vulnerability



Extent/Range of Intensity

The Special Events Assessment Rating (SEAR) is the single federal interagency resource used for assessing and categorizing domestic events that do not rise to the level of a National Security Special Event (NSSE). Using a risk-based approach to weigh vulnerabilities and consequences against threats, the SEWG develops the SEAR levels based primarily on event information submitted by S/L/T/T officials in the annual Data Call.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Significant special events where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government are potential targets for attacks such as terrorist attacks and civil disorder. Regardless of the purpose for the event, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from just about any of the hazards detailed in this risk assessment could have compounded and devastating impacts. It is not possible to calculate a specific vulnerability across Missouri. However, because of the desire for publicity following terrorist-type attacks at special event venues, it is more likely that counties with greater population densities would be the target of such attacks.

Changing Future Conditions Considerations

As Missouri continues to attract special events with local, state and/or national level awareness, the potential for vulnerabilities increases. Proper planning for large scale events plays a significant role in mitigating potential impacts. As weather hazards potentially strengthen due to a changing climate, special events will see increased vulnerability due to intensified weather incidents.

Risk Summary/Problem Statement

Using the major transportation corridors for the State and population as key indicators, the counties at most risk are Boone, Buchanan, Clay, Franklin, Greene, Jackson, Jasper Jefferson, St. Charles, and St. Louis County; as well as the City of St. Louis. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

Description/Location

Special events present a unique set of challenges and security issues, including vulnerability to both man-made and natural hazards. Special events can include sporting events, concerts, political events, and events with religious significance, and can be handled at the local, state or federal level, depending on the size and scope of the event itself. Security for some special events can be handled with local- and state-level coordination, while some events rise to a level of national significance requiring a National Special Security Event designation and federal agency input and direction. Special events usually occur in larger cities, though this isn't always the case. When planning for special events, security officials should account for vulnerability to both natural and man-made hazards.

National Special Security Events

A number of factors are taken into consideration when designating an event as a national special security event (NSSE), including the following:

- **Anticipated attendance by dignitaries**—Events that are attended by officials of the United States government and/or foreign dignitaries may create an independent federal interest in ensuring that the event transpires without incident and that sufficient resources are brought to bear in the event of an incident.
- **Size of the event**—A large number of attendees and participants generally increases the security requirements. In addition, larger events are more likely to draw the attention of terrorists or other criminals, particularly those interested in employing weapons of mass destruction.
- **Significance of the event**—Some events have historical, political, and/or symbolic significance that may heighten concern about possible terrorist acts or other criminal activity.
- **Duration of the event** – State and local law enforcement and public safety agencies may possess the manpower and other resources to provide adequate security for a major event in their jurisdiction, but are unable to do so for events over several days or weeks and at the same time continue to meet the routine obligations of the greater community.
- **Availability of state and local resources** –State and local resources may lack the expertise, experience or manpower needed to ensure comprehensive protection.
- **Multiplicity of jurisdictions** – The event may require extensive coordination of law enforcement agencies between multiple jurisdictions.
- **Threat Assessment** – Terrorism, extensive illegal disobedience or other criminal activity is anticipated.

The Secretary of Homeland Security (DHS) is responsible for designating events as NSSEs. Homeland Security Presidential Directive (HSPD-5) grants the Secretary this authority. The Secretary is assisted in the NSSE designation process by **the NSSE Working Group**, comprised of interagency subject matter experts and co-chaired by the U.S. Secret Service (USSS), the Federal Bureau of Investigation, and the Federal Emergency Management Agency. The NSSE Working Group is responsible for conducting an assessment of each event being considered for NSSE designation. When the Secretary of Homeland Security designates an event as an NSSE, the Secret Service assumes its mandated role as the lead federal agency for the design and implementation of the operational security plan and coordinator for all federal resources deployed to maintain the level of security needed for the designated events. The Federal Bureau of Investigation (FBI) serves as the lead agency responsible for intelligence and law enforcement operations as well as statutory federal criminal investigations. The goal of such an operation is to prevent terrorist attacks and criminal acts.

Once an event is designated as an NSSE, the Secret Service employs existing partnerships with federal, state, and local law enforcement and public safety officials to coordinate provision of a safe and secure environment for the event and those in attendance.

Resources used as part of past NSSE operational security plans that could be deployed for upcoming NSSE designated events include physical infrastructure security fencing and barricades, special access accreditation badges, K-9 teams, and other security technologies.

The Emergency Preparedness and Response division within the U.S. Department of Homeland Security could preposition some combination of the following assets: the Domestic Emergency Support Team, Urban Search and Rescue teams, national Emergency Response Teams, the Nuclear Incident Response Team, the Strategic National Stockpile and Mobile Emergency Response System. The specific package will be tailored for each individual event based on coordination with other federal agencies, state and local jurisdictions, available local resources, mutual aid agreements, and other event-specific requirements.

Extent

Special Events Assessment Rating

Coordinated by the Department of Homeland Security/Office of Operations Coordination and Planning (OPS), the Special Events Working Group (SEWG) is the core of an interagency process that involves over 50 Departments, agencies and components of the federal government. Federal input and recommendations concerning special events are provided based on their respective authorities, responsibilities, and fields of expertise. The SEWG is the single forum that ensures comprehensive and coordinated Federal interagency awareness of and support to designated Special Events.

The Department of Homeland Security (DHS) Special Events Program utilizes the annual Data Call conducted in conjunction with the State, Local, Territorial and Tribal (S/L/T/T) Homeland Security Advisors. The Program provides an objective, calendared framework through which Federal, State and local entities can identify special events occurring within their jurisdictions.

The Special Events Assessment Rating (SEAR) is the single federal interagency resource used for assessing and categorizing domestic events that do not rise to the level of a National Security Special Event (NSSE). Using a risk-based approach to weigh vulnerabilities and consequences against threats, the SEWG develops the SEAR levels based primarily on event information submitted by S/L/T/T officials in the annual Data Call.

- **SEAR-I**: Events of significant national and/or international importance that may require extensive Federal interagency security and incident management preparedness. Pre-deployment of Federal assets as well as consultation, technical advice and support to specific functional areas in which the State and local agencies may lack expertise or key resources may also be warranted.
- **SEAR II:** Significant events with national and/or international importance that may require direct national level Federal support and situational awareness. The magnitude and significance of these events calls for close coordination between Federal, state, and local authorities and may warrant limited pre-deployment of USG assets as well as consultation, technical advice and support to specific functional areas in which the State and local agencies may lack expertise or key resources.
- **SEAR-III**: Events of national and/or international importance that require only limited direct Federal support to augment local capabilities. Generally, state and local authorities adequately

support these events; however, the significance of these events generally warrants national situational awareness and, depending on the jurisdiction, may require limited direct support from specific Federal agencies.

- **SEAR-IV**: Events with limited national importance that are generally handled at the State and local level. Unusual circumstances may sometimes necessitate the employment of specific Federal resources to address unique needs of a particular event. Existing Federal assistance programs are available to state and local jurisdictions hosting the event for training, exercise, and/or tailored program support.
- **SEAR-V**: Events that may be nationally recognized but generally have local or state importance. Federal departments and agencies will receive notice of these events for situational awareness purposes, but in most cases minimal, if any, Federal assets or resources will be expended to assist with management of these events. Federal officials will not normally actively monitor or coordinate support for these events unless specifically requested.

Description/Location

Significant special events may include any type of event where large groups of people are gathered together, regardless of the cause or purpose of the event, where expanded security and other resources are required above and beyond the resources typically available to local and/or state government. In such instances, event sponsors, in conjunction with local and state authorities, are responsible for coordinating the event and requesting federal assistance, if necessary.

Special events may be motivated by political, economic or social causes, as in the case of inaugurations, state of the union addresses, and summit conferences, or by recreational causes, as with the Olympics and other major sporting events (Super Bowl, World Series, etc.). Special events may also include large holiday events such as the annual Fair St. Louis 4th of July Celebration, where large numbers of people crowd onto the Mississippi Riverfront in St. Louis.

The perception of inherent dangers and threats facing the country and Missouri has changed significantly since the terrorist attacks of September 11, 2001, and subsequent attacks on mass gatherings since the 2001 attack have reinforced the need for planning and security for these types of events. Anytime a large number of people are congregated in one area, an incident resulting from just about any of the hazards could have devastating impacts. For example, consider the impact a sudden, severe hailstorm could have on the population visiting the Fair St. Louis, which well over one million people usually attend each year. A severe hailstorm struck the north St. Louis County area in April 2001, causing thousands of dollars of damage to residences and vehicles. This storm produced baseball-size (and larger) hailstones, which killed many pets and nearly all the waterfowl residing at local park ponds. An incident such as this could have devastating impacts if it were to suddenly strike the fairgrounds with over one million people in attendance and without shelter (not to mention the potential impact a terrorist attack incident could impose at such an event). Medical services would likely be overwhelmed with the number of injuries.

Extent

Special events are vulnerable to both man-made and natural hazards, and each of these hazards presents its own set of parameters on the extent of impacts. A special event itself generally presents a large group of people condensed into a limited space, which can exacerbate the impacts from hazards by offering additional opportunity for injuries and fatalities.

The severity of incidents occurring in conjunction with designated special events could range from low to high, depending on many factors. The severity of these incidents will be a function of the number of people attending these events and the type and impacts of the specific hazards that affect the events. Considerations of severity could range from a hoax bomb scare or terrorist threat where no one is physically injured and without any property damage to a full-scale natural disaster affecting a large number of people gathered at one time with mass injuries and property damage by natural, accidental, terrorist, or criminal causes.

Previous Occurrences

Atlanta, Georgia, Centennial Olympic Park Bombing

On Saturday July 27, 1996, Georgia Bureau of Investigation (GBI) agents in Atlanta were dispatched to the Centennial Olympic Park for what seemed like a routine public disturbance call on the ninth day of the 1996 Summer Olympics. Apparently, some rowdy partygoers had been creating a scene at the event.

By the time GBI agents arrived, the partiers were gone. However, a security guard pointed out another problem: a green knapsack left unattended under a nearby bench. Because of the suspicious nature of the situation, a bomb diagnostic team was called as officers attempted to keep people away from the area without creating a panic. They were unaware that a warning call had been made to 911 emergency dispatchers.

About 20 minutes later, as agents were assessing the situation and continuing to attempt to steer people away from the abandoned bag, it blew up with a powerful explosion. The blast killed one visitor and injured more than 100. All of the law officers at the scene were injured except for one. A Turkish cameraman died of a heart attack while covering the explosion.

FBI said of this incident, "The fatal bombing in Atlanta was a terrorist attack aimed at thousands of innocent persons gathered at the Olympic Park." This blast was the worst attack on an Olympic Games since 11 Israeli athletes were killed by Palestinian guerrillas at the 1972 games in Munich, Germany.

St. Louis, Missouri, Papal Visit

Pope John Paul II visited St. Louis, Missouri, on January 26 and 27, 1999. This pastoral visit included 30 hours of speeches, parades, prayer services, and a papal mass for about 104,000 people at the St. Louis America's Center, which filled every available seat in the center, including the Edward Jones Dome and adjoining convention exhibit hall. This mass is billed as the largest U.S. indoors gathering ever and was designated a National Special Security Event.

This two-day series of events also included a welcome address by President Bill Clinton and ceremonial farewell meeting with Vice-President Al Gore and was attended by many state officials, including Missouri Governor Mel Carnahan. Event activities were spread throughout the St. Louis metropolitan area, from the Lambert–St. Louis International Airport to the downtown area and the grounds of the Gateway Arch on the Mississippi Riverfront.

This was undoubtedly one of the largest single special event to occur in Missouri, with security concerns reaching to national and international levels. Close coordination between local, state, and federal law enforcement agencies is required to provide adequate security measures for events like this. The potential for hazards from mass transportation accidents was also elevated for this event, as one quote said, "Seemingly every school bus in the region was enlisted to transport people from suburban pickup

points down into St. Louis America's Center for the papal mass." Fortunately, this event was conducted without any major incidents.

St. Louis, Missouri, World Agricultural Forum Conference

The Hyatt Regency Hotel at Union Station in St. Louis hosted the World Congress meeting of the World Agricultural Forum May 18 to 20, 2003. The forum brought together agriculture industry leaders and world leaders to discuss the future of global agriculture. Mindful of Seattle's experience with violent protestors who disrupted the World Trade Organization (WTO) meeting there in December 1999, St. Louis police were braced for any possible problems that could arise from hundreds or even thousands of protestors descending on St. Louis for this event.

Four Seattle police officers were invited to St. Louis to talk about what happened at the 1999 WTO event (50,000 demonstrators overwhelmed 400 Seattle officers and protestors smashed windows and vandalized cars as police fought back with rubber bullets and tear gas). Washington, DC, police were also invited to St. Louis to share their experiences with riots during protests of major global conferences in their city.

Although St. Louis police were not anticipating the same level or intensity of violence as in Seattle, they did have intelligence reports that some visitors would be in St. Louis who were involved in the Seattle protests and other demonstrations. Another conference, called Biodevastation 7, was scheduled immediately prior to the World Agricultural Forum (May 16 to 18, 2003) in St. Louis, which involved a gathering of opponents to genetic engineering. An organizer with the group had indicated that 200 to 800 people were expected to attend the Biodevastation 7 conference and that there would be 200 to 2,000 protestors at the World Agricultural Forum.

During this time period, in nearby Creve Coeur, Missouri, extra police were also on hand at the Monsanto property for the annual Creve Coeur Days. Monsanto, an agriculture industry leader, is a host of the annual celebration, which includes carnival rides and game booths on its property. Creve Coeur police coordinated a plan with St. Louis police to gather information about possible protests at this event.

A local international security consulting firm was in charge of security for the World Agricultural Forum conference. They worked with St. Louis police and other law enforcement agencies to prepare for possible protests at the event. Close coordination between these agencies helped to ensure that St. Louis was prepared to provide adequate security for the event and the international visitors to the city. Other than a couple of minor incidents between police and activists in the days leading up to the conference, no incidents were reported. A protest outside the conference on May 18 drew only a few hundred demonstrators, all peaceful, and only a handful of demonstrators were present during the event's two days.

Indiana State Fair Stage Collapse

On August 13, 2011, a strong wind gust from an approaching severe thunderstorm hit the temporary roof structure of a stage during a country music concert at the Indiana State Fair in Indianapolis, Indiana. The roof structure collapsed, injuring 58 people and killing seven. Forecasts throughout the day of the show had called for severe weather in the evening, and discussions had been held whether to still hold the show. Despite recommendations to cancel due to incoming inclement weather, the show went on as scheduled.

Boston Marathon Bombing

On April 15, 2013, thousands of runners competed in the 117th annual Boston Marathon. The Marathon is held in Boston Massachusetts on Patriot's Day, and is the world's oldest annual marathon. The event attracts an average of 30,000 registered athletes and 500,000 spectators each year. A little before 3 PM, two bombs detonated near the finish line of the race, killing three and injuring several hundred other runners and spectators. The incident highlighted the vulnerability of large groups of people to an explosive device, and spawned a citywide manhunt that resulted in the death of one suspect and capture of another.

Between September 1998 and March 2022, about 72 separate events were considered National Special Security Events (NSSEs) nationwide. These events included Super Bowl 56, Presidential Inaugurations and Addresses, world summits and National Conventions for the two major American political parties. None of these events occurred in Missouri.

Probability of Future Hazard Events

Missouri will undoubtedly host future special events that will require significant security and other emergency planning considerations. The overall probability that a disastrous incident from any cause would occur in conjunction with a designated special event or special security event is considered moderate, depending on the event in question. The probability for an incident to occur during any particular special event is really a function of the hazards previously detailed in this hazard analysis and the probability of the independent occurrences of these hazards. However, special events will unfortunately continue to be likely targets for protests, rioting, and terrorist attacks in the United States. Refer to the measure of probability and severity discussions on the other hazards for more specific considerations.

Changing Future Conditions Considerations

As Missouri continues to attract special events with local, state and/or national level awareness, the potential for vulnerabilities increases. Proper planning for large scale events plays a significant role in mitigating potential impacts. As weather hazards potentially strengthen due to a changing climate, special events will see increased vulnerability due to intensified weather incidents.

State Vulnerability Overview

Significant special events where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government are potential targets for attacks such as terrorist attacks and civil disorder. Regardless of the purpose for the event, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from just about any of the hazards detailed in this risk assessment could have compounded and devastating impacts.

It is not possible to calculate a specific vulnerability across Missouri. However, because of the desire for publicity following terrorist-type attacks at special event venues, it is more likely that counties with greater population densities would be the target of such attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists, though this doesn't make them immune from attacks. It is expected that the likelihood of attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a

desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc.) for large numbers of people.

Vulnerability is also not limited to terrorist attack. Tornadoes, lightning, hail and other severe weather can cause damages, injuries and death to crowds exposed to the elements at special events that are held outdoors.

State Estimates of Potential Losses

Potential losses for this hazard include all infrastructure, critical facilities, humans and animals. The degree of impact would be directly related to the type of incident. Potential losses would include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses, loss of human life, and injuries to persons. Secondary effects of infrastructure failure could include public safety hazards, spread of disease, increased morbidity and mortality among the local and distant populations and public panic.

As discussed previously, it is difficult to describe vulnerability in terms of the jurisdictions, since the nature of special events varies widely. A well attended one-time event could be subject to as much loss as a less well attended annual event. For the purposes of this plan, this loss estimate will take into account a hypothetical scenario in order to calculate potential dollar losses. Please note that this hypothetical scenario is included to provide one methodology for local jurisdictions to estimate potential losses. The hypothetical scenario is an IED attack. Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) which utilizes scenarios put together by the Department of Homeland Security.

****THE FOLLOWING HYPOTHETICAL SCENARIO IS FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets.

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Table 3.89. Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons

Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners).	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Hazard Impact on Future Growth and Development

As Missouri plays host to more national events and large scale venues the potential for losses increases. Proper planning for large scale events plays a significant role in mitigating future losses.

Risk Summary

Significant special events are any type of event where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government. Special events may be motivated by political, economic, religious or social causes, as in the case of inaugurations, state of the union addresses, and summit conferences, or they may be motivated by recreational causes as with major sporting events or designated holiday events. With major sporting events and arenas, major league and collegiate sports teams, concerts and festivals, Missouri sees a significant number of events per year that can and do require special planning for the safety and security of attendees.

Regardless of the purpose or cause, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from just about any of the hazards presented in this plan could have devastating impacts, compounded by the sheer number of people located in a condensed area.

In such instances, event sponsors, in conjunction with local and state authorities, are responsible for coordinating the event and requesting assistance at the federal level, if necessary. Local and state authorities are responsible for coordinating requirements from the organization sponsoring an event and determining resource shortfalls and submitting resource requests, through the existing structures and mechanisms, to the national level for consideration. Event sponsors are responsible for developing concepts for conducting the event, identifying resource requirements necessary to support the event, and submitting resource requests to local and state governments for consideration.

Problem Statement:

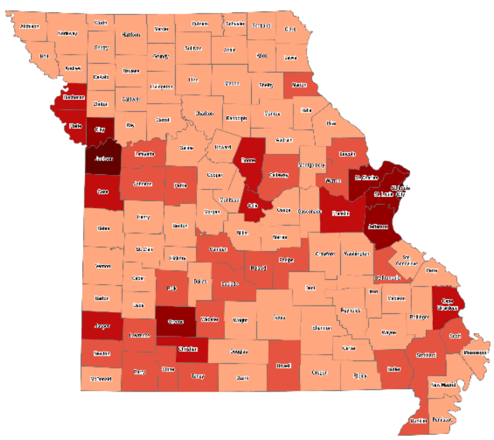
Using the major transportation corridors for the State and population as key indicators, the counties at most risk for Mass Transportation incident are Boone, Buchanan, Clay, Franklin, Greene, Jackson, Jasper Jefferson, St. Charles, and St. Louis County; as well as the City of St. Louis. Mitigation strategies and limited resources would best be allocated in these counties.

2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.20. Terrorism

Description

Terrorism, as defined by the Federal Bureau of Investigation (FBI), is "the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." The effects of terrorism can vary significantly, including loss of life, injuries to people and properties, and disruptions in services (e.g., water supplies, public transportation, and communications).

Vulnerability	Extent/Range of Intensity
	Extent is reliant on the type of attack and other parameters. Terrorism is usually attempted to kill or injure persons, destroy property or impact critical functions, and affect public confidence and instill fear.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Terrorist acts could easily undermine the confidence that people have in their own security and in their government's ability to protect them from harm. Because bombs can be made so easily, the threat of a bomb should not be taken lightly. The threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the persons making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community. A strategic nuclear, biological, or chemical attack on the United States could have the most devastating and far-reaching consequences. The use of these weapons against the United States is unlikely. Unfortunately, however, as long as such weapons exist, there is always a chance that they could be used.

Changing Future Conditions Considerations

Changing future conditions in terms of climate and weather patterns are not expected to have a direct impact on the probability or severity of potential terrorism events. However, there are extreme environmental groups that may resort to forms of terrorism in their protests.

Risk Summary/Problem Statement

Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

Description/Location

Terrorism, as defined by the Federal Bureau of Investigation (FBI), is "the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." The effects of terrorism can vary significantly, including loss of life, injuries to people and properties, and disruptions in services (e.g., water supplies, public transportation, and communications).

According to the FBI, there are two primary types of terrorism:

- **Domestic Terrorism** involves groups or individuals whose terrorist activities are intended to further ideological goals stemming from domestic influences, such as those of a political, religious, social, racial, or environmental nature.
- **International Terrorism** involves terrorist activity committed by groups or individuals who are inspired by, or associated with, designated foreign terrorist organizations or nations (state-sponsored).

Forms of Terrorism

Terrorism can take place in various forms, depending on the technological means available to the terrorist group, the nature of the issue motivating the attack, and the points of weakness of their target. Potential terrorist actions include the following:

- **Bombings**—Bombings have long been used in terrorist attacks and probably represent the most "traditional" form of terrorism. These types of incidents range from small-scale letter bombs to large-scale attacks on specific buildings. Other bomb-related incidents frequently involve "suicide bombers," who sacrifice themselves for their cause.
- **Airline Attacks**—In the past, terrorist acts involving aircraft were generally restricted to hijackings and bombings. However, the attacks on the World Trade Center buildings in New York City in 2001 brought a new avenue to light—the use of commercial aircrafts to attack infrastructure targets. Surface-to-air missile attacks also present a threat to U.S. aircrafts.
- **Weapons of Mass Destruction (WMD) Attacks**—WMD attacks usually involve nuclear weapons or biological or chemical agents. Chemical and biological agents are infectious microbes or toxins used to produce illness or death. They can be dispersed as aerosols or airborne particles directly onto a population, producing an immediate effect (a few seconds to a few minutes) or a delayed effect (several hours to several days). Severity of injuries depends on the type and amount of the agent used and duration of exposure. Because some biological agents take time to grow and cause disease, an attack using this type of agent may go unnoticed for several days.
- **Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) Attacks** - Of all the possible disasters and hazards included in this risk assessment, a strategic chemical, biological, radiological nuclear, or explosives (CBRNE) attack could have the most devastating and far-reaching consequences. The use of these weapons against the United States is unlikely. Unfortunately, however, as long as such weapons exist, there is always a chance that they could be used. CBRNE could entail WMD and use of nuclear weapons, or more direct attacks, like anthrax related attacks to individuals.
- **Infrastructure Attacks**—These types of attacks can impact various potential targets, including water distribution systems and treatment plants, utility companies and services, emergency services, gas and oil production facilities, telecommunications centers, transportation terminals, media facilities, government buildings, and religious institutions.

- **Cyberterrorism**—Cyberterrorism pertains to attacks on computer-based systems that are designed to spread disinformation and propaganda, deny service to legitimate computer users, spread electronic viruses to corrupt vital data, or cause critical infrastructure outages. Political conflicts that have led to attacks on cyber systems include clashes between India and Pakistan, Israel and the Palestinians, the North Atlantic Treaty Organization, and Serbia. Cyber Disruptions are covered separately in **Section 3.3.14.**
- **Agroterrorism**—Agroterrorism involves intentional contamination of commercial produce or meat supplies. Because the United States supplies approximately 16 percent of the world's meat, 40 percent of its soybeans, and 41 percent of its corn, a deadly fungus or bacteria could be devastating. Of the 222 possible bioterrorism attacks that have occurred worldwide in the twentieth century, only 17 of these targeted commercial livestock or plants, according to the Institute for National Strategic Studies.
- **Arson**—Intentional fires have caused extensive damage during terrorist-related incidents in the past. These types of incidents may also be associated with bombings and usually target specific structures, such as churches. Although deliberately set fires have been reported at 15 churches in Missouri, none have been determined to be hate crime-related or terrorist-related incidents.
- **Kidnappings/Assassinations**—Kidnappings and assassinations may also be terrorist-related incidents, but because these events generally involve few individuals, their effect on emergency management operations may be minimal in terms of response.
- **Lone Offenders** – Terrorist threats have evolved from large-group conspiracies toward lone-offender attacks. These individuals often radicalize online and mobilize to violence quickly. Without a clear group affiliation or guidance, lone offenders are challenging to identify, investigate, and disrupt.
- **The Internet and social media** – International and domestic violent extremists have developed an extensive presence on the Internet through messaging platforms and online images, videos, and publications. These facilitate the groups' ability to radicalize and recruit individuals who are receptive to extremist messaging. Social media has also allowed both international and domestic terrorists to gain unprecedented, virtual access to people living in the United States in an effort to enable homeland attacks. The Islamic State of Iraq and ash-Sham (ISIS), in particular, encourages sympathizers to carry out simple attacks wherever they are located—or to travel to ISIS-held territory in Iraq and Syria and join its ranks as foreign fighters. This message has resonated with supporters in the United States and abroad.

Domestic Terrorism

According to the FBI, domestic terrorist groups represent interests that span the full spectrum of political and economic viewpoints, as well as social issues and concerns. The current domestic terrorist threat comes primarily from white supremacists, black separatists, animal rights/environmental terrorists, anarchists, antiabortion extremists, and self-styled militia.

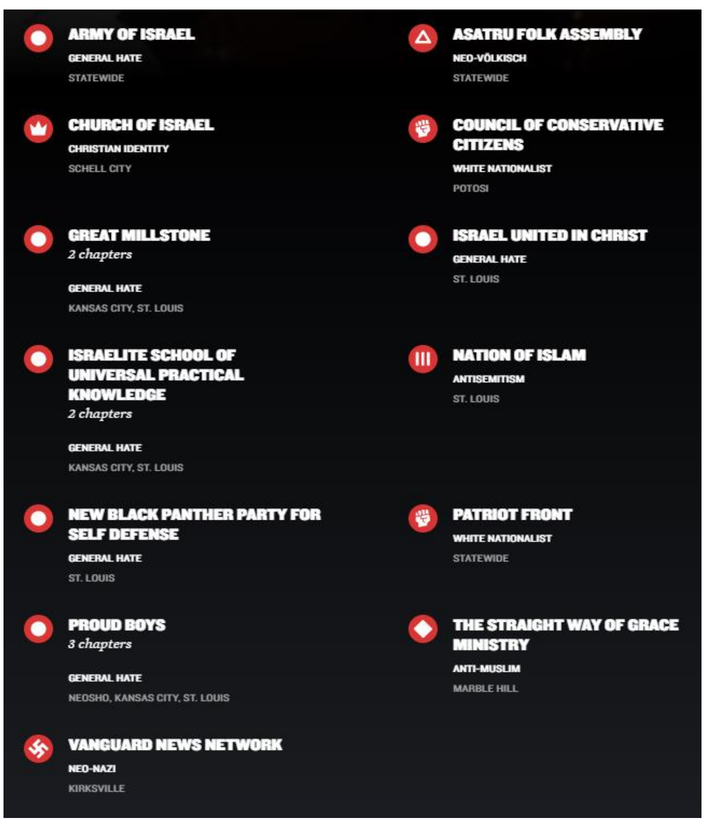
- **White Supremacists or Right-Wing Extremists**—Right-wing extremist groups often adhere to the principles of racial supremacy and embrace antigovernment, antiregulatory beliefs. Generally, extremist right-wing groups engage in activities that are protected by constitutional guarantees of free speech and assembly. Examples of this type of group include Aryan Nations, the Order, and Posse Comitatus. Missouri has seen some activity from these groups in the past few years. According to the Southern Poverty Law Center, Missouri has two extremist groups operating within its borders. Although a state statute against paramilitary training exists, one of

these groups is also known to have such a facility in Missouri. In addition, several special gatherings of extremist groups have taken place within the State in recent years.

- **Black Separatists**—United States-based black separatist groups follow radical variants of Islam and in some cases express solidarity with al-Qa'ida and other international terrorist groups.
- **Animal Rights and Environmental Extremists**—Operating under the umbrella of the Animal Liberation Front and Earth Liberation Front, often seek to end or mitigate perceived cruelty, harm, or exploitation of animals or perceived exploitation or destruction of natural resources and the environment. These extremists use a variety of tactics against their targets, including arson, sabotage/vandalism, theft of research animals, and the occasional use of explosive devises
- **Anti – Government/Anti-Authority Violent Extremists** —The potential for violence by anarchists and other emerging revolutionary groups, such as the Anarchist Black Cross Federation (ABCF), will continue to be an issue for law enforcement. The stated goals of the ABCF are "the abolishment of prisons, the system of laws, and the capitalist state." The ABCF believes in armed resistance to achieve a stateless and classless society. The ABCF has continued to organize, recruit, and train anarchists in the use of firearms.
- **Anti-Abortion Extremists**—The FBI investigates anti-abortion groups. Potential violent anti-abortion extremists linked to terrorism ideologies or groups pose a current threat.

The Southern Poverty Law Center tracks hate groups, which it classifies as "any group with beliefs or practices that attack or malign an entire class of people – particularly when the characteristics being maligned are immutable." **Figure 3.165** shows SPLC-identified hate groups in Missouri.

Figure 3.165. Identified Hate Groups in Missouri



Source: Southern Poverty Law Center, 2022

International Terrorism

The United States continues to face a formidable challenge from international terrorism. In general terms, the international terrorist threat can be divided into three categories: loosely affiliated extremists operating under the radical jihad movement, formal terrorist organizations, and state sponsors of terrorism. Each of these categories, which represent threats to U.S. citizens and interests both abroad and at home, are described below:

- **Loosely Affiliated Extremists**—These are motivated by political or religious beliefs and pose the most urgent threat to the United States.
- **Formal Terrorist Organizations**—These organizations are typically autonomous and have their own infrastructures, personnel, financial arrangements, and training facilities.
- **State Sponsors of Terrorism**—This category includes countries known to sponsor terrorism and to view it as a tool of foreign policy. Currently, the U.S. Department of state recognizes seven countries in this category: Iran, Iraq, Sudan, Libya, Syria, Cuba, and North Korea.

Foreign Terrorist Organizations (FTOs) are foreign organizations that are designated by the secretary of state in accordance with Section 219 of the Immigration and Nationality Act, as amended by the Antiterrorism and Effective Death Penalty Act of 1996. A list is compiled every two years. As of March 2022, the current list of FTOs designates the following organizations (see **Table 3.90**):

Table 3.90. Designated Foreign Terrorist Organizations

Date Designated	Name
10/8/1997	Abu Sayyaf Group (ASG)
10/8/1997	Aum Shinrikyo (AUM)
10/8/1997	Basque Fatherland and Liberty (ETA)
10/8/1997	Gama'a al-Islamiyya (Islamic Group) (IG)
10/8/1997	HAMAS
10/8/1997	Harakat ul-Mujahidin (HUM)
10/8/1997	Hizballah
10/8/1997	Kahane Chai (Kach)
10/8/1997	Kurdistan Workers Party (PKK) (Kongra-Gel)
10/8/1997	Libera`tion Tigers of Tamil Eelam (LTTE)
10/8/1997	National Liberation Army (ELN)
10/8/1997	Palestine Liberation Front (PLF)
10/8/1997	Palestinian Islamic Jihad (PIJ)
10/8/1997	Popular Front for the Liberation of Palestine (PFLF)
10/8/1997	PFLP-General Command (PFLP-GC)
10/8/1997	Revolutionary People's Liberation Party/Front (DHKP/C)
10/8/1997	Shining Path (SL)
10/8/1999	al-Qa'ida (AQ)
9/25/2000	Islamic Movement of Uzbekistan (IMU)
5/16/2001	Real Irish Republican Army (RIRA)
12/26/2001	Jaish-e-Mohammed (JEM)
12/26/2001	Lashkar-e Tayyiba (LeT)
3/27/2002	Al-Aqsa Martyrs Brigade (AAMB)
3/27/2002	Asbat al-Ansar (AAA)
3/27/2002	al-Qaida in the Islamic Maghreb (AQIM)
8/9/2002	Communist Party of the Philippines/New People's Army (CPP/NPA)
10/23/2002	Jemaah Islamiya (JI)
1/30/2003	Lashkar i Jhangvi (LJ)

Date Designated	Name
3/22/2004	Ansar al-Islam (AAI)
7/13/2004	Continuity Irish Republican Army (CIRA)
12/17/2004	Islamic State of Iraq and the Levant (formerly al-Qa'ida in Iraq)
6/17/2005	Islamic Jihad Union (IJU)
3/5/2008	Harakat ul-Jihad-i-Islami/Bangladesh (HUJI-B)
3/18/2008	al-Shabaab
5/18/2009	Revolutionary Struggle (RS)
7/2/2009	Kata'ib Hizballah (KH)
1/19/2010	al-Qa'ida in the Arabian Peninsula (AQAP)
8/6/2010	Harakat ul-Jihad-i-Islami (HUJI)
9/1/2010	Tehrik-e Taliban Pakistan (TTP)
11/4/2010	Jundallah
5/23/2011	Army of Islam (AOI)
9/19/2011	Indian Mujahedeen (IM)
3/13/2012	Jemaah Anshorut Tauhid (JAT)
5/30/2012	Abdallah Azzam Brigades (AAB)
9/19/2012	Haqqani Network (HQN)
3/22/2013	Ansar al-Dine (AAD)
11/14/2013	Boko Haram
11/14/2013	Ansaru
12/19/2013	al-Mulathamun Battalion (AMB)
1/13/2014	Ansar al-Shari'a in Benghazi
1/13/2014	Ansar al-Shari'a in Darnah
1/13/2014	Ansar al-Shari'a in Tunisia
4/10/2014	ISIL Sinai Province (formally Ansar Bayt al-Maqdis)
5/15/2014	al-Nusrah Front
8/20/2014	Mujahidin Shura Council in the Environs of Jerusalem (MSC)
9/30/2015	Jaysh Rijal al-Tariq al Naqshabandi (JRTN)
1/14/2016	ISIL-Khorasan (ISIL-K)
5/20/2016	Islamic State of Iraq and the Levant's Branch in Libya (ISIL-Libya)
7/1/2016	Al-Qa’ida in the Indian Subcontinent
8/17/2017	Hizbul Mujahideen (HM)
2/28/2018	ISIS-Bangladesh
2/28/2018	ISIS-Philippines
2/28/2018	ISIS-West Africa
5/23/2018	ISIS-Greater Sahara
7/11/2018	al-Ashtar Brigades (AAB)
9/6/2018	Jama’at Nusrat al-Islam wal-Muslimin (JNIM)
4/15/2019	Islamic Revolutionary Guard Corps (IRGC)
1/10/2020	Asa’ib Ahl al-Haq (AAH)
1/14/2021	Harakat Sawa’d Misr (HASM)
3/11/2021	ISIS-DRC
3/11/2021	ISIS-Mozambique
12/1/2021	Segunda Marquetalia
12/1/2021	Revolutionary Armed Forces of Colombia – People’s Army (FARC-EP)

Source: U.S. Department of State, https://www.state.gov/foreign-terrorist-organizations/

Government Authority

After the attacks on September 11, 2001, parts of 22 domestic agencies were consolidated into one department, the U.S. Department of Homeland Security (DHS), to protect the nation against future terrorist threats. Roles of those agencies include analyzing threats and intelligence, guarding national

borders and airports, protecting critical infrastructure, and coordinating response efforts for future emergencies.

The FBI is the lead federal agency for investigating terrorism. The FBI is authorized to open an investigation whenever “facts or circumstances reasonably indicate that two or more persons are engaged in an enterprise for the purpose of furthering political or social goals wholly or in part through activities that involve force or violence and a violation of the criminal laws of the United States.” In any given year, the FBI engages in approximately 24 full-scale domestic terrorism investigations. The Terrorist Screening Center, commonly known as the “watchlist” is the U.S. government’s consolidated database containing sensitive law enforcement and national security information concerning the identity information of those who are known to be or reasonably suspected of being involved in terrorist activities.

An essential weapon in the battle against terrorists is the Joint Terrorism Task Force (JTTF). A national JTTF, located at FBI Headquarters, includes representatives from the U.S. Department of Defense, U.S. Department of Energy, FEMA, Central Intelligence Agency, Customs Service, Secret Service, and the Immigration and Naturalization Service. Additionally, there are 200 task forces around the country where representatives from federal agencies, state and local law enforcement personnel, and first responders work together to track down terrorists and prevent acts of terrorism in the United States. There are two JTTFs in Missouri, one in Kansas City and one in St. Louis.

After terrorist-related events, communities may receive assistance from state and federal agencies operating within the existing Integrated Emergency Management System. FEMA is the lead federal agency for supporting state and local response to the consequences of terrorist attacks.

National Terrorism Advisory System (NTAS)

Because of the potential for future terrorist-related incidents, a national security alert system in place to disseminate information regarding the risk of terrorist acts to federal, state, and local governments and to the American people. The National Terrorism Advisory System (NTAS) consists of two types of advisories – Bulletins and Alerts. Bulletins communicate current developments or general trends regarding threats of terrorism. NTAS Bulletins permit the Secretary of Homeland Security to communicate critical terrorism information that, while not necessarily indicative of a specific threat against the United States, can reach homeland security partners or the public quickly, thereby allowing recipients to implement necessary protective measures. Because DHS may issue NTAS Bulletins in circumstances not warranting a more specific warning, NTAS Bulletins provide the Secretary with greater flexibility to provide timely information to stakeholders and members of the public.

When there is specific, credible information about a terrorist threat against the United States, DHS will share an NTAS Alert with the American public when circumstances warrant doing so. The Alert may include specific information, if available, about the nature of the threat, including the geographic region, mode of transportation, or critical infrastructure potentially affected by the threat, as well as steps that individuals and communities can take to protect themselves and help prevent, mitigate or respond to the threat. The Alert may take one of two forms: Elevated, if there is credible threat information, but only general information about timing and target such that it is reasonable to recommend implementation of protective measures to thwart or mitigate against an attack, or Imminent, if DHS believes the threat is credible, specific, and impending in the very near term.

Threat conditions are assigned by the secretary of Homeland Security in consultation with the attorney general and other appropriate federal agency heads, including other members of the Homeland Security Council. Threat conditions may be set for the entire nation or a particular geographic area or industrial sector. The assigned threat conditions are reviewed at regular intervals to determine whether adjustments are warranted.

Missouri's Homeland Security Program

The Missouri Office of Homeland Security (OHS) is a part of the Department of Public Safety, and directly under the Director of the Department of Public Safety (DPS).

Figure 3.166. Missouri Department of Public Safety – Organizational Chart

	Office of the Director	
Division of Fire Safety	Missouri Capitol Police	Missouri Adjutant General
Missouri State Highway Patrol	Missouri Homeland Security	State Emergency Management Agency
Division of Alcohol & Tobacco Control	Missouri Veterans Commission	Missouri Gaming Commission

Source: Missouri Department of Public Safety, http://dps.mo.gov/dir/programs/ohs/documents/OHSOverview05-17-13.pdf

Office of Homeland Security

The homeland security coordinator, who works directly for the director of the Department of Public Safety, manages the Office of Homeland Security and is tasked with implementing Missouri's Homeland Security Strategy. The coordinator is responsible for the overall Homeland Security program in Missouri, and works with the Homeland Security Advisory Council, the Regional Homeland Security Oversight Committees, and the various initiatives to ensure that Missouri's program is focused on an all threats, all hazards approach. Two "special assistants" support the different OHS initiatives. The Office of Homeland Security serves as Missouri's State Administrative Agency (SAA) and handles the administration and fiscal aspects of the Homeland Security Grant Program, Emergency Management Grant Program and the Juvenile Justice Program.

Governor's Homeland Security Advisory Council

The Governor's Homeland Security Advisory Council (HSAC) was established through Executive Order 05-20. The HSAC currently consists of 38 members. The chairman of the HSAC is the director of the Department of Public Safety. The vice chairman is the homeland security coordinator, who also heads the Missouri Office of Homeland Security.

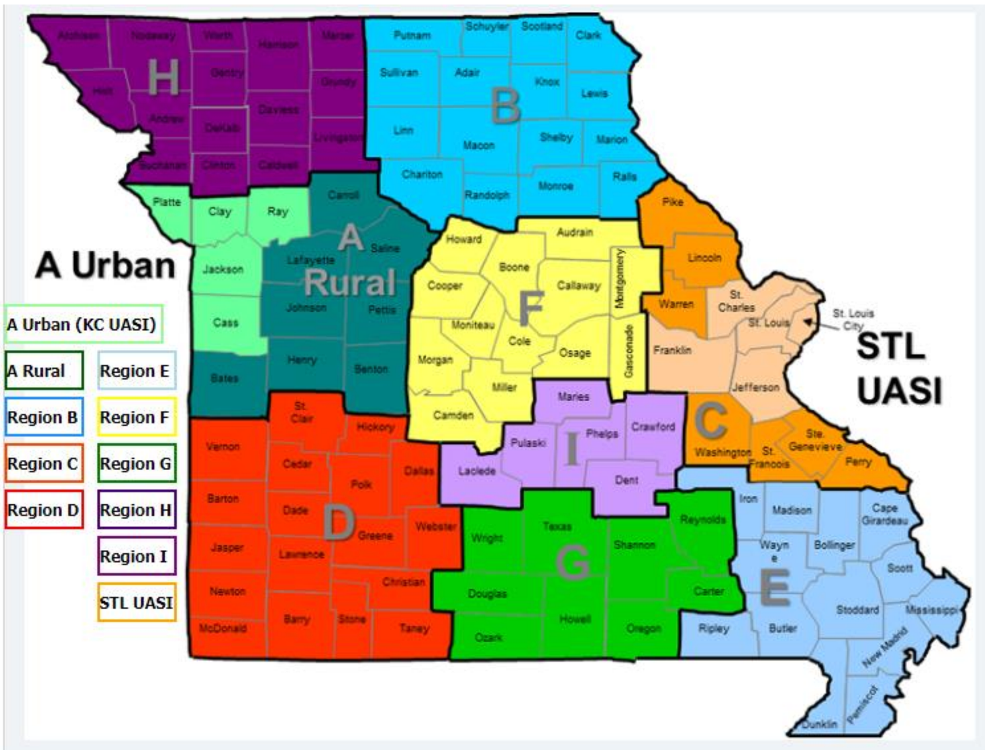
Regional Homeland Security Oversight Committees

Local communities are focused and engaged in Missouri's homeland security program through the establishment of regional advisory groups, called Regional Homeland Security Oversight Committees (RHSOCs). RHSOCs fall under the governance structure of the Homeland Security Advisory Council.

Missouri's "Homeland Security Regionalization" program is focused on establishing a common sense, logical governance structure and process to facilitate local, community level engagement in not only grant funding priorities and strategies, but other homeland security related decisions consistently across the state. fourteen core disciplines at the county/local level have been identified as minimum voting participants in these regional committees.

While only one individual from each discipline in a specific region will hold a voting seat on the committee, it is mandated that they represent all segments of their core discipline members in their region, including both county and local interest. They accomplish this through establishment of working groups within each discipline. The RHSOCs meet quarterly (January, April, July, and October), with additional meetings called as needed to discuss special topics.

Figure 3.167. Homeland Security Regions



Source: Missouri Department of Public Safety, https://dps.mo.gov/dir/programs/ohs/regionalization/

Extent

Extent is reliant on the type of attack and other parameters. Terrorism is usually attempted to kill or injure persons, destroy property or impact critical functions, and affect public confidence and instill fear.

Biological and chemical weapons have often been used to terrorize an unprotected population, instead of actual use as weapons of war. However, the potential damage that can occur in the event of such an attack is huge, particularly to human health. Chemical, biological, radiological, nuclear, and explosive (CBRNE) attacks against the United States as a whole, and against individual states or local entities, can be categorized as originating from either domestic or international sources. However, because the impacts on life and property would largely be the same regardless of the source of such an attack, similar preparedness, response, and recovery activities apply.

A single nuclear weapon detonation could cause massive destruction, and all aforementioned types of attacks could cause extensive casualties. An all-out nuclear attack could affect the entire population in the vicinity of the impacted area. Some areas would experience direct weapons effects: blast, and initial nuclear radiation. Other areas would experience indirect weapons effects, primarily radioactive fallout. As long as world leaders maintain rational thinking, the probability of an attack by a nation-state remains low but does not rule out attack by a terrorist group.

Secondary effects of these attacks, which could severely stress the country, include lack of adequate shelter, food, water, health and medical facilities and personnel, and mortuary services; disruption of communication systems; and power outages. Because of the potential devastation and significant secondary effects caused by this type of attack, the severity is rated high.

Previous Occurrences

The following section highlights noteworthy terrorist-related threats and actual attacks that have occurred in the United States since 1970. The French Revolution provided the first uses of the words "Terrorist" and "Terrorism." Use of the word "terrorism" began in 1795 in reference to the Reign of Terror initiated by the Revolutionary government. The agents of the Committee of Public Safety and the National Convention that enforced the policies of "The Terror" were referred to as "Terrorists." The French Revolution provided an example to future states in oppressing their populations. It also inspired a reaction by royalists and other opponents of the Revolution who employed terrorist tactics such as assassination and intimidation in resistance to the Revolutionary agents. The Parisian mobs played a critical role at key points before, during, and after the Revolution. The following section highlights noteworthy terrorist-related threats and actual attacks that have occurred in the United States since 1970.

In **1972**, members of a U.S. fascist group called Order of the Rising Sun were found in possession of 30 to 40 kilograms of typhoid bacteria cultures, which they planned to use to contaminate water supplies in Chicago, St. Louis, and other large Midwestern cities.

In **1984**, two members of an Oregon cult headed by Bhagwan Shree Rajneesh cultivated Salmonella bacteria and used it to contaminate restaurant salad bars in an attempt to affect the outcome of a local election. Although approximately 751 people became ill and 45 were hospitalized, there were no fatalities.

In **February 1993**, an improvised bomb exploded in a rental van parked on the second level of the World Trade Center's parking basement. The bomb contained approximately 1,200 to 1,500 pounds of a homemade fertilizer-based explosive, urea nitrate. The blast produced a crater 150 feet in diameter and five floors deep. Although the motive for the attack was never confirmed, it is believed that the suspect who masterminded the bombing was either backed by a loose network of militant Muslims or directed by Iraq. The incident, which killed 6 people and injured more than 1,000, was the most significant international terrorist act that had ever been committed on U.S. soil at that time.

In **April 1995**, a massive bomb exploded inside a rental truck parked near the Murrah Federal Building in Oklahoma City, destroying half the nine-story building and killing 168 people. The incident was traced to Timothy McVeigh, who was convicted of the bombing and executed by lethal injection in June 2001. He was the first federal prisoner to be executed in 38 years. McVeigh was a survivalist who believed individual rights (e.g., gun control) were being deprived by government agencies. Consequently, he was convinced he acted to defend the Constitution and saw himself as a crusader and hero. This was the worst terrorist event, either domestic or international in origin that had ever occurred in the United States at that time.

In **March 1995**, four members of the Minnesota Patriots Council, a right-wing militia organization advocating the violent overthrow of the U.S. government, were convicted of conspiracy charges under the Biological Weapons Anti-Terrorism Act of 1989 for planning to use ricin, a lethal biological toxin. The four men allegedly conspired to assassinate federal agents who served papers on one of them for tax violations.

In **May 1995**, a member of the neo-Nazi organization Aryan Nations was arrested in Ohio on charges of mail fraud. He allegedly misrepresented himself when ordering three vials of freeze-dried Yersinia Pestis, the bacteria that causes bubonic plague, from a Maryland biological laboratory.

In **October 1995**, the Amtrak Sunset Limited passenger train derailed near Hyder, Arizona. It was determined that the train track had been sabotaged, causing the train to derail and topple 30 feet from a bridge. A letter signed by the Sons of Gestapo was left at the scene. One person was killed and 83 others were injured in this incident.

In **November 1995**, members of the Tri-States Militia (a group composed of militia from at least 30 states) were arrested after being linked to five would-be terrorists whose bomb plots were thwarted by federal and state law enforcement agencies. The plots involved blowing up the Southern Poverty Law Center, offices of the Anti-Defamation League, federal buildings, abortion clinics, and gay community locations.

In **December 1995**, an Arkansas man was charged with possession of ricin in violation of the Biological Weapons Anti-Terrorism Act. The man was arrested and subsequently hanged himself in his jail cell the next day.

In **July 1996**, a pipe bomb exploded in Atlanta's Centennial Olympic Park as the city was hosting the summer Olympic Games. One person was killed and dozens were wounded. It was later determined that the bomb had been planted by Eric Robert Rudolph, who was also suspected of being responsible for a double bombing at the Sandy Springs Professional Building in Atlanta in January 1997 and a double bombing at the Otherside Lounge in Atlanta in February 1997. Rudolph was arrested in May 2003 after five years on the run. He is a former soldier and survivalist with extreme right-wing views and is also reported to have ties to white supremacist groups.

On **September 11, 2001** there were a series of coordinated terrorist suicide attacks by Islamic extremists upon the United States of America. Nineteen terrorists affiliated with al-Qaeda hijacked four commercial passenger jet airliners. Each team of hijackers included a trained pilot. The hijackers intentionally crashed two of the airliners (United Airlines Flight 175 and American Airlines Flight 11) into the World Trade Center in New York City, one plane into each tower (1 WTC and 2 WTC), resulting in the collapse of both buildings soon afterward and extensive damage to nearby buildings. The hijackers crashed a third airliner (American Airlines Flight 77) into the Pentagon in Arlington County, Virginia, near Washington, D.C. Passengers and members of the flight crew on the fourth aircraft (United Airlines Flight 93) attempted to retake control of their plane from the hijackers; that plane crashed into a field near the town of Shanksville in rural Somerset County, Pennsylvania. In addition to the 19 hijackers, 2,974 people died as an immediate result of the attacks, and the death of at least one person from lung disease was ruled by a medical examiner to be a result of exposure to WTC dust. Another 24 people are missing and presumed dead. The victims were predominantly civilians. The New York City Fire Department lost 341 New York City Fire Department firefighters and 2 paramedics, while 23 New York Police Department, 37 Port Authority Police Department officers, and 8 private ambulance personnel were killed. There were 125 victims in the Pentagon. The dead included 8 children. The youngest victim was a 2-year-old child on Flight 175, the oldest an 82 year-old passenger on Flight 11. According to the Associated Press, the city identified over 1,600 bodies but was unable to identify the rest (about 1,100 people). They report that the city has "about 10,000 unidentified bone and tissue fragments that cannot be matched to the list of the dead." Bone fragments were still being found in 2006 as workers prepared

the damaged Deutsche Bank Building for demolition. The average age of all the dead in New York City was 40.

The attacks created widespread confusion across the United States. All international civilian air traffic was banned from landing on US soil for three days; aircraft already in flight were either turned back or redirected to airports in Canada or Mexico. Unconfirmed and often contradictory reports were aired and published throughout the day. One of the most prevalent of these reported that a car bomb had been detonated at the U.S. State Department's headquarters, the Truman Building in Foggy Bottom, Washington, D.C.

Between early October and early **December 2001**, five people died from anthrax infection, and at least 13 others contracted the disease in Washington, DC; New York City; Trenton, New Jersey; and Boca Raton, Florida. Anthrax spores were found in a number of government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination.

In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Almost all of the incidents turned out to involve no actual biohazard. Nevertheless, emergency responders typically treated each call as a potentially serious health and safety risk. During this tense time, in Missouri, the Department of Health and Senior Services (DHSS) issued numerous health alert advisories to local officials and the public, providing guidance on how to handle anthrax or suspicious letters and packages during a time of extremely heightened tensions. DHSS also instituted a surveillance system, contacting health providers to obtain public health information twice weekly, while also working to improve the public health infrastructure, information sharing, health communication networks, and hospital surge capabilities.

In **October 2002**, a month-long sniper spree terrorized the entire Washington DC area as a sniper duo gunned down ten people at random. The shooters were later arrested while sleeping in their modified vehicle.

In **2005**, the FBI arrested 11 people in relation to 17 attacks that included $12 million in arson damage to Vail Ski Resort in Vail, Colorado.

In **March 2008**, a homemade bomb damaged an Armed Forces Recruiting Office in Times Square in New York City. No suspect was caught.

In **April 2013**, two explosions occurred at the finish line of the Boston Marathon, killing three people and injuring more than 180. The attack resulted in a three-day manhunt for two suspects, one of which was apprehended and the other killed by police. A “shelter in place” order was given for residents in the Boston area as the search weaved in and out of area neighborhoods.

In **December 2013**, a 58-year-old avionics technician in Wichita, Kansas was arrested for attempting a suicide bombing at Wichita Mid-Continental Airport. The perpetrator became radicalized after reading propaganda on the Internet. He was arrested while driving a vehicle into the airport with what he believed to be an active explosive device.

In **June 2015**, a mass shooting took place at an Episcopal church in Charleston, South Carolina, one of the oldest black churches in the country and a site for community organization around civil rights. Nine people were killed, and a tenth victim was shot but survived. The perpetrator was later arrested and confessed that he was trying to initiate a race war.

In **June 2016**, a lone gunman opened fire at a gay nightclub in Orlando, FL. Almost 50 people were killed and 53 were injured in what is currently the deadliest mass shooting in modern American history.

In **October 2017**, a gunman opened fire from the Mandalay Bay Hotel on the Route 91 Harvest Festival concert in Las Vegas. At least 59 people were killed, and more than 850 other people were injured in the assault.

In **August 2017**, hundreds of white nationalists and their supporters gathered for a rally over plans to remove a Confederate statue were met by counter-protesters. An assailant drove his vehicle into a crowd of counter-protesters at the "Unite the Right" rally in Charlottesville, Virginia, United States. One person, identified as Heather D. Heyer, was killed and 28 people were injured in the assault.

In **February 2018**, an assailant armed with a semi-automatic rifle entered Building 12 at Marjory Stoneman Douglas High School and opened fire on students and teachers in Parkland, Florida, United States. At least 17 people were killed, and 17 other people were injured in the assault. The event sparked a new movement against gun violence – March for Our Lives – where young people were advocating for stricter gun laws.

In **October 2018**, an assailant opened fire on a baby-naming ceremony at the Tree of Life Synagogue in Squirrel Hill, Pittsburgh, Pennsylvania. At least eleven people were killed and seven other people, including the assailant and four police officers, were injured in the assault.

In **August 2019**, an assailant, armed with a rifle, opened fire on civilians inside a Walmart in El Paso, Texas, United States. At least 23 people were killed, and 24 other people were injured in the assault. The victims included United States, Mexican, and German nationals. The shooter stated that he was targeting Mexicans.

In **January 2021**, an insurrection at the U.S. Capitol occurred to prevent the certification of the election of Joe Biden as president. Five people died as a result of the event. The Capitol insurrection involved small numbers of organized white supremacists and anti-government extremists, but also QAnon adherents and large numbers of ordinary Trump supporters. As of January 2022, more than 700 people have been charged in connection with the Capitol attacked.

CBRNE Attacks

During World War I (1915–1918), chemical and conventional weapons were used. The first poison gas, chlorine, was used by the Germans against Allied troops in 1915. The effects of the gas were devastating, causing severe choking attacks within seconds of exposure. The British subsequently retaliated with chlorine attacks of their own, although reportedly more British suffered than Germans, because the gas blew back into their own trenches. Phosgene was later used in the war because it caused less severe coughing, resulting in more of the agent being inhaled. Then, in September 1917, mustard gas was used in artillery shells by the Germans against the Russians. Mustard gas caused serious blisters, both internally and externally, several hours after exposure. In all, there were 1,240,853 gas-related casualties and 91,198 deaths from gas exposure during World War I.

During **World War II** (1941–1945), atomic (nuclear), chemical, and conventional weapons were used. Use of chemical weapons in World War II was not as prevalent as in World War I and was primarily limited to the Japanese Imperial Army. During the war, the Japanese used various chemical-filled munitions, including artillery shells, aerial bombs, grenades, and mortars, against Chinese military forces and civilians. Chemical agents used included phosgene, mustard, lewisite, hydrogen cyanide, and diphenyl cyan arsine. The war was brought to an abrupt end in 1945, when the United States dropped two atomic bombs on Japan: one on Hiroshima that obliterated the entire city and killed approximately 66,000 people and another on Nagasaki that destroyed about half the city and killed about 39,000 people.

During the **Vietnam War** (1964–1973), chemical and conventional weapons were used. Chemical weapons used during the Vietnam War are believed to have only involved tear agents used by the United States and possibly psychedelic agents, also by the United States. Although not directly used as warfare agents, toxic herbicides such as Agent Orange were commonly used as defoliants by the United States. Long-term exposure to Agent Orange, which contained the contaminant dioxin, was believed to cause illness and disease in humans.

In 1983, **Iraq** launched its first of 10 documented chemical attacks against Iran. The largest of these attacks was in February 1986, when mustard gas and the nerve agent tabun were used, impacting up to 10,000 Iranians. Although the exact number of chemical attacks implemented by Iraq during the war is unknown, the Iranian government estimates that more than 60,000 soldiers had been exposed to mustard gas and the nerve agents sarin and tabun by the time the war ended in 1988. Based on these data, the Iraqi chemical attacks during the Iran-Iraq war were the largest since World War I.

Although several isolated attacks involving biological agents have occurred over the last few decades, a series of incidents in the United States that gained nationwide exposure occurred between early October and early December 2001, when five people died from anthrax infection, and at least 13 others contracted the disease in Washington, DC; New York City; Trenton, New Jersey; and Boca Raton, Florida. Anthrax spores were found in a number of government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination. In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Fortunately, almost all of these incidents turned out to involve no actual biohazard.

The Global Terrorism Database provides information on more than 150,000 global and domestic terrorism incidents at https://www.start.umd.edu/gtd/. The following are brief descriptions of selected CBRNE related incidents that have occurred in the United States between 2004 and 2019 (2019 is the last year for available data).

- **February 2, 2004:** In Washington, DC, ricin was discovered in a United States Senator's Office. Fortunately, there were no reports of illness or injury. No group claimed responsibility.
- **March 14, 2005:** Trace amounts of potential anthrax were found at a Department of Defense mail facility in Washington, DC. Workers were given antibiotics as a precautionary measure. No injuries or damages were reported, and no group claimed responsibility.

- **May 5, 2005:** In New York City, New York, two small improvised explosive devices (IEDs) exploded outside of the building housing the British Consulate, causing damage, but no injuries. No group claimed responsibility.
- **October 26, 2007:** In New York City, New York, an unknown assailant threw two explosive devices into the compound of the Mexican Consulate causing minor damage, but no injuries. No group claimed responsibility.
- **December 12, 2008:** At about 5:30 pm in Woodburn, Oregon, an improvised explosive device (IED) located at a bank exploded killing two police officers and injuring another police officer and a bank employee. The bank was damaged. No group claimed responsibility.
- **December 25, 2009:** A would-be suicide bomber on-board Northwest Flight 253 bound for Detroit, Michigan from Amsterdam, Netherlands detonated a device that was attached to his body while on the plane. The bomb was a six-inch packet of high explosives containing pentaerythritol, triacetone triperoxide, other materials and a syringe. The explosives were sown into his underwear. The assailant was wounded, and damage was done to the aircraft. A passenger who tried to put the explosion out was also injured. There were 290 people in total were on board. No other injuries or casualties were reported. Al Qaeda in the Arabian Peninsula claimed responsibility.
- **May 10, 2010:** A pipe bomb exploded at a mosque during evening prayers in Jacksonville, Florida. Sixty people were inside the building praying, but no one was injured or killed. There were no claims of responsibility.
- **January 7, 2011:** An envelope addressed to Homeland Security Secretary Janet Napolitano ignited at a postal sorting facility in Washington D.C. The envelope was not opened and therefore did not cause any casualties or property damage. No group claimed responsibility for the attack.
- **June 18, 2012:** An assailant attempted to bomb a natural gas pipeline in Plano, Texas. The assailant was critically injured when the explosive device detonated prematurely. Additionally, the pipeline was also damaged in the blast. No group claimed responsibility; however, sources note that the assailant identified as part of the anti-government Sovereign Citizens movement.
- **August 12, 2012:** Assailants threw an explosive device containing acid and other chemicals at the College Preparatory School of America, an Islamic school in Lombard, Illinois. No casualties or property damage was reported. No group claimed responsibility for this attack.
- **April 15, 2013:** An explosive device consisting of a pressure cooker, nails, BBs and a detonator fashioned from the remote control of a toy car detonated near the finish line of the Boston Marathon. Two bombs detonated approximately 12 seconds and 100 yards apart. Approximately 264 people were wounded in the two attacks. The alleged assailants were identified and either arrested or killed.
- **November 4, 2014:** Two explosive devices planted in a backpack were discovered and safely defused in Vickery Creek Park in Roswell, Georgia. An individual claimed responsibility and stated that he planted the devices in order to demonstrate that incidents of terrorism can occur anywhere.

- **August 2, 2015:** An explosive device detonated in a mailbox outside Calvary Baptist Church in Las Cruces, New Mexico. There were no reported casualties in the blast. The was one of two similar blasts targeting churches in Las Cruces on the same day; a third device was discovered and safely defused outside of First Presbyterian Church in Las Cruces on August 14, 2015. No group claimed responsibility for these incidents.
- **November 1, 2015:** An assailant threw an explosive device at a Walmart in Tupelo, Mississippi. There were no reported casualties in the blast. An individual claimed responsibility for the incident; reports stated he targeted the Walmart because they stopped selling Mississippi state flags containing the Confederate flag symbol.
- **December 2, 2015:** Two assailants opened fire on a holiday party at the Inland Regional Center for Disabled People in San Bernardino, California; the assailants attempted to trigger an explosive device, though it failed to detonate. Fourteen people were killed and at least seventeen were wounded in the attack. No group claimed responsibility.
- **September 17, 2016:** An explosive device detonated in the Chelsea neighborhood of Manhattan, New York City. This was one of four related attacks carried out by the assailant in the area. At least 29 people were injured in the blast. Ahmad Khan Rahami claimed responsibility for this incident. Sources suspected that Rahami may have been inspired by Abu Muhammad al Adnani, a spokesperson for the Islamic State of Iraq and the Levant (ISIL).
- **August 4, 2017:** A package delivered to an Internal Revenue Service (IRS) office made employees sick in Kansas City, Missouri, United States. At least 10 people reported being ill, which included vomiting and nausea. No group claimed responsibility for the attack.
- **October 29, 2018:** A letter bomb addressed to the Cable News Network (CNN) office was discovered and defused at a mailing sorting facility in Atlanta, Georgia, United States. This was one of 16 coordinated mail bomb attacks between October 22, 2018 and November 1, 2018 that targeted critics of President Donald Trump. Letter bombs were also sent to former president, Barack Obama, Joe Biden, Kamala Harris, James Clapper (National Intelligence Director), and others. Cesar Altieri Sayoc was arrested in connection with the incidents.

Probability of Future Hazard Events

The threat of terrorism in the United States remains a concern. Over the past few years, the level of acts committed in the United States has increased steadily with attacks ranging from mass shootings to improvised explosive devices to cyber-attacks.

Although several different extremist groups have been identified in Missouri, there have been no indications of any specific recent terrorist activities. The potential does remain, however, for new extremist and/or terrorist groups to move into the State at any time.

An open society such as ours, which depends on technology for its continued smooth operation, remains a potential target for terrorists. Large cities with a variety of news media outlets probably represent the most likely locations for terrorist acts because terrorists generally want their acts to reverberate in the news media and reach the largest audience possible. Since Missouri does not have large media markets compared to some states, it is not as likely a target for terrorist activity as those other states. However, the Oklahoma City bombing debunked the idea that rural America is completely

safe from terrorists. With this in mind, it appears that a terrorist attack could occur in Missouri; the probability of such an attack is low and noted as <1-percent.

Should Missouri experience a terrorist attack, the severity of such an attack could range from high to low depending on the type of attack. For instance, if a building was blown up and no lives were lost, the severity of the attack would be low. However, if a terrorist group decided to contaminate a large urban area's water supply with a poisonous chemical, the severity of the attack could be very high due to the number of people directly affected by the poisoned water, as well as damage to that community's sense of well-being. An attack of this nature could easily result in mass hysteria and insecurity concerning the government's ability to protect its citizens.

Local communities are focused and engage in Missouri's Homeland Security Program through the establishment of regional advisory groups, called Regional Homeland Security Oversight Committees (RHSOCs). RHSOCs fall under the governance structure of the Homeland Security Advisory Council. Missouri's program is focused on establishing a common sense, logical governance structure and process to facilitate homeland security related decisions consistently across the State. There are currently several initiatives underway.

Changing Future Conditions Considerations

Changing future conditions in terms of climate and weather patterns are not expected to have a direct impact on the probability or severity of potential terrorism events. However, there are extreme environmental groups that may resort to forms of terrorism in their protests.

Additionally, As time passes, relationships between countries across the globe evolve from adversarial conditions to friendship and back; these relationships can be strained by a variety of factors, including energy shortages, water availability and changing weather patterns. No matter the cause, increasing volatility of relations on the national stage can increase the risk of CBRNE, and other types of terrorist attacks on the homeland.

State Vulnerability Overview

Terrorist acts could easily undermine the confidence that people have in their own security and in their government's ability to protect them from harm. Because bombs can be made so easily, the threat of a bomb should not be taken lightly. The threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the persons making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community.

A strategic nuclear, biological, or chemical attack on the United States could have the most devastating and far-reaching consequences. The use of these weapons against the United States is unlikely. Unfortunately, however, as long as such weapons exist, there is always a chance that they could be used. The potential for traditional war-related attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information, however, even attacks of that variety are rare. Attackers are likely to have either very specific targets such as Women's clinics, or desire large publicity from the attacks.

State Estimates of Potential Losses

It is not possible to calculate a specific vulnerability for each county in Missouri. However, because of the desire for publicity following attacks, it is more likely that counties with greater population densities

would be the target of attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists. It is expected that the likelihood of attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc.) for large numbers of people. A description of population density is contained in this plan in **Section 3.1.1** and a map **Figure 3.6** showing the population density of each Missouri county is found in **Table 3.3**.

Potential losses for this hazard include all infrastructure, critical facilities, humans and animals. The degree of impact would be directly related to the type of terrorist incident. Potential losses would include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses, loss of human life, and injuries to persons. Secondary effects of infrastructure failure could include public safety hazards, spread of disease, increased morbidity and mortality among the local and distant populations and public panic. Terrorist events are rare occurrences and specific amounts of estimated losses for previous occurrence are not available due to the complexity and multiple variables associated with these types of hazards.

As discussed previously, it is difficult to quantify potential losses in terms of the jurisdictions most threatened by terrorist attack events due to the many variables and human element that come in to play. Therefore, for the purposes of this plan, the loss estimates will take into account hypothetical scenarios. Please note that these hypothetical scenarios are included to provide one methodology for local jurisdictions to estimate potential losses. The hypothetical scenarios include: a chemical attack, a biological attack, an IED attack, and a radiological attack. For comparative purposes, these hypothetical attack scenarios will be staged at the same venue, a baseball stadium. The hypothetical stadium is situated on less than one square mile and has a seating capacity of over 45,000 persons. Surface area and parking structures are located adjacent to the stadium.

Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and `Planning Scenarios (EMCAPS) which utilizes scenarios put together by the Department of Homeland Security.

****THE FOLLOWING HYPOTHETICAL SCENARIOS ARE FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

Chemical Attack – Mustard Gas

Scenario Overview: Mustard gas is released from a light aircraft onto a stadium during a sporting event. The agent directly contaminates the stadium and the immediate surrounding area. This particular type of attack would cause harm to humans and could render portions of the stadium unusable for a short time period in order to allow for a costly clean-up. There might also be a fear by the public of long-term contamination of the stadium and subsequent boycott of games resulting in a loss of revenue and tourism dollars.

Assumptions: (1) The population density at the stadium on game day is high – approximately 75 percent of the seats, 31,000, are filled. (2) Sulphur mustards are extremely toxic and may damage eyes, skin and respiratory tract. Death sometimes results from secondary respiratory infections. (3) The rate of “worried well” is equal to 9 times the number of infected cases.

Described Losses:

Severe Eye Injuries (1-2 hours)	23,250 persons
Severe Airway Injuries (1-2 hours)	23,250 persons
Severe Skin Injuries (2 hrs to days)	27,900 persons
Total “Worried Well” Cases (9 times the number of affected cases)	251,000 persons
Deaths	620 persons

Notes: Victims will require decontamination and both long and short term treatment. Services may need to be suspended at the area until all investigations are conducted.

Biological Attack – Pneumonic Plague

Scenario Overview: Canisters containing aerosolized pneumonic plague bacteria are opened in public bathrooms. Each release location will directly infect 110 people; hence, the number of release locations dictates the initial infected population. The secondary infection rate is used to calculate the total infected population. This particular weapon of mass destruction (WMD) attack method would not cause damages to buildings or other infrastructure, only to human populations.

Assumptions: (1) The population density at the stadium on game day is high. (2) The population density of the stadium city is high (5,724 persons / sq mile). (3) The number of dispersion devices is 30. Devices are assumed to be placed in crowded seating areas. (4) Pneumonic plague has a 1-15 percent mortality rate in treated cases and a 40-60 percent mortality rate in untreated cases. (5) The rate of “worried well” is equal to 9 times the number of infected cases.

Described Losses:

Initial Infected Populations	3300 persons
Secondary Infected Population	16,629 persons
Total Plague Cases	19,929 persons
Total Deaths (Treated Cases 7%)	1,395 persons
Total “Worried Well” Cases (9 times the number of infected cases)	179,361 persons

Improvised Explosive Device Attack – ANFO

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets.

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons

Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners.)	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Radiological Dispersion Device – Dirty Bomb Attack

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets. The bomb also contains 2,700 Curies of Cesium-137 (Cs-137).

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons
Radiological Poisoning Injuries that Need Aggressive Treatment	6
Radiological Poisoning Injuries that Need Non-Critical Treatment	220
Radiological Poisoning Injuries that could Self-Medicate with Proper Public Information	31,188
Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners.)	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Hazard Impact on Future Growth and Development

Unfortunately, areas of dense population and large public venues may make attractive targets for a terrorist attack. As more and more large public events are held in Missouri, and as the population increases, more potential exists for these venues to become targets of a terrorist attack. However, with manmade hazards such as this that can have multiple variables involved, increases in development is not necessarily always a factor in determining risk.

Risk Summary

A terrorist can attack a society in many ways. Since the September 11, 2001 attacks renewed terrorism into the public consciousness, the Nation has seen dozens of attacks qualified as terrorism across the

country, including shootings, stabbings, cyber-attacks, bombings and biological agents. The relatively open society Americans take pride in unfortunately offers an ever-present (though low) risk of a terrorist attack occurring where citizens live and work. Fortunately, the combined efforts of local, state and federal law enforcement and concerned citizens have thwarted a majority of these attacks.

Currently, the New START (Strategic Arms Reduction Treaty) agreement, entered into force on February 5, 2011, reduces nuclear weapons in both Russia and the United States to 1,550 warheads. The treaty is expected to last through 2026. Even though the START treaties have reduced the overall number of nuclear weapons and many chemical/biological weapons stockpiles have been destroyed, incidents involving these types of weapons continue to occur worldwide.

Missouri and the Nation must continue to plan for, and be prepared for, this type of hazard (CBRNE or WMD). In many ways, while the risk of a nuclear exchange by the superpowers is greatly reduced, the potential risk of proliferation of weapons of mass destruction is greater than during the Cold War era.

While it may not be possible to prevent such an attack, steps can be taken to lessen the likelihood and the potential effects of an incident by implementing certain measures:

- Identifying and organizing resources
- Conducting a risk or threat assessment and estimating losses
- Identifying mitigation measures that will reduce the effects of the hazards and developing strategies to deal with the mitigation measures in order of priority
- Implementing the measures and evaluating the results (and keeping the plan up-to-date)

Problem Statement:

Using the major transportation corridors for the State and population as key indicators, the counties at most risk are Boone, Buchanan, Clay, Franklin, Greene, Jackson, Jasper Jefferson, St. Charles, and St. Louis County; as well as the City of St. Louis. Mitigation strategies and limited resources would best be allocated in these counties.

2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.21 Structural and Urban Fires

Description

Structural fires are a major problem that can affect any area of the State. As defined by the National Fire Protection Agency (NFPA), a structure fire is defined as “any fire inside, on, under, or touching a structure.” Because buildings exist anywhere people live and work, fires can occur at anytime and anyplace throughout the State. Minor urban fires can be expected often in Missouri. Major fires occur several times a year, particularly in dense, urban areas with aging building stock. Fires impact many aspects of society in terms of economic, social, and other indirect costs.

Vulnerability

Extent/Range of Intensity

The impact of a fire to a single-story building in a small community may be as great as that of a larger fire to a multistory building in a large city. A variety of factors will determine the extent of damage to the individual structure. Damage can range from minor to substantial with damages far exceeding the value of the structure. Factors that impact fire extent include structure type, age, density of development, presence of flammable substances, and more.

Probability	Severity	Location
Less than 1%	Low to High	Statewide

State Vulnerability Overview

Structural and urban fires are a daily occurrence throughout the State. According to the U.S Fire Administration, approximately 2.2 fatalities per 1,000 fires occur annually in Missouri, as well as numerous injuries affecting the lives of the victims, their families, and many others—especially those involved in fire and medical services. Unlike other disasters, structural fires are often insidious and despicable due to the prevalence of arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services, or the costs of supporting the criminal justice system. According to this vulnerability analysis Greene, Jackson, and St. Louis counties, and the City of St. Louis have a high vulnerability to structural and urban fires.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard. The wildland-urban interface (WUI) is commonly described as the zone where structures and other human development meet and intermingle with undeveloped wildland or vegetative fuels. A warmer, drier climate create favorable conditions for wildfires which may increase the potential for structural fires within the WUI zones.

Risk Summary/Problem Statement

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. The greatest risk of interaction by fires with other hazards may involve damaging earthquakes. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural and urban fires.

Description/Location

Structural fires are a major problem that can affect any area of the State. The Missouri Division of Fire Safety (MDFS) indicates that approximately 73 percent of the fire departments in Missouri are staffed with volunteers dedicated to the task of fire prevention and suppression. Whether paid or volunteer, these departments are often limited by lack of resources and financial assistance. The impact of a fire to a single-story building in a small community may be as great as that of a larger fire to a multistory building in a large city.

Because fires can occur anywhere in the State, the MDFS continues to actively promote the enactment of a statewide fire code. Although no statewide code has been enacted to date, successful legislative efforts to improve fire safety have included the following:

- Fire, Safety, Health, and Sanitation Inspections of Child Care Facilities (RSMo 210.252)
- Boiler and Pressure Vessel Safety Act (RSMo 650.200)
- Elevator Safety Act (RSMo 701.350)
- Fireworks Safety Act (RSMo 320-111)
- Amusement Ride Safety Act (RSMo 316.200-211)
- Inspections of Long Term Care Facilities (RSMo 198.074)
- Missouri Blasting Safety Act (RSMo 319.300)

Fires impact many aspects of society in terms of economic, social, and other indirect costs. According to the MDFS, the costliest crime in the State is arson. This should be a great concern to citizens, law enforcement, the judicial system, and the fire service sector. Fires caused by arson impact citizens through higher insurance premiums, lost jobs, loss of lives, injuries, and property loss. Primary duties of the State Fire Marshal include the investigation of fires, explosions, and any related occurrences. The investigative staff is responsible for investigating any fire requested by fire service and law enforcement within the State. This also includes explosions, bombings, and all other related offenses.

The MDFS Division of Fire Safety Fire investigators, who are Missouri POST licensed law enforcement officers, are on call 24 hours a day, seven days a week. This staff must cover all 114 counties and is dedicated to assisting any local or state agency and conducting quality investigations. The investigators are trained in several fields of expertise, including arson for fraud, explosives recognition, and post-blast training.

The MDFS Training and Certification Unit develops and oversees the training curriculum being provided regionally for state certification of firefighters, fire investigators, fire inspectors, fire officers, fire service instructors, and emergency responders dealing with hazardous materials. Although firefighter certification is not mandatory in Missouri, MDFS has issued more than 95,000 certifications at various levels to more than 36,000 individuals.

Also, the MDFS coordinates a statewide fire mutual aid system. In the event of a major emergency or statewide disaster, all fire protection agencies in the state become an organizational part of the Missouri Fire Mutual Aid System. Also included in the system are specialized teams and resources, including hazardous materials teams, swift water rescue resources, fire-based medical assets and other technical rescue capabilities. The system is organized into nine emergency response regions. Each team is available to assist agencies in the management of major fires and manmade or natural disasters. The system is based on the tenets of the National Incident Management system and adheres to the principal

that every incident remains under the control of the affected jurisdiction. **Figure 3.168** shows the Fire/Rescue Mutual Aid Regions in Missouri.

Figure 3.168. Missouri Fire and Mutual Aid Regions

Source: MDFS, Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE), http://dfs.dps.mo.gov/documents/forms/MO_815-F0072.pdf

Through the mutual aid system, MDFS coordinates K9 team resources. Handlers who wish to be considered for mutual aid deployment must complete a registration form and return it to the Division of Fire Safety for inclusion in the mutual aid resource database. MDFS is primarily interested in registering area and disaster search K9/handler teams, for both live and human remains detection, while tracking/trailing, accelerant detection, bomb detection, and law enforcement K9 teams are also encouraged.

The MDFS is responsible for the enforcement of fireworks laws throughout Missouri. In addition to conducting inspections of any facilities involved with fireworks, over 1,500 permits are issued seasonally to manufacturers, wholesalers, and retailers of fireworks who can sell to the public from approximately June 20th to July 10th and from Dec. 20th to Jan. 2nd each year. Persons conducting public fireworks shows are required to obtain a fireworks operator license issued by the MDFS. Illegal fireworks are a concern, because they can be dangerous, causing loss of lives, severe injuries, and property damage.

Extent /Range of Intensities

As defined by the National Fire Protection Agency (NFPA), a structure fire is defined as "any fire inside, on, under, or touching a structure." This definition includes any mobile property used as a fixed structure, such as manufactured homes and portable buildings, but does not include roadworthy vehicles such as recreation vehicles (National Fire Protection Agency, 2019). A variety of factors will determine the extent of damage to the individual structure. Damage can range from minor to substantial with damages far exceeding the value of the structure. Factors include:

- Structure type and age
- Building codes addressing fire prevention, detection, and extinguishments
- Density of development
- Presence of flammable substances
- Fire department response speed
- Firefighting technology
- Training of local fire management officials and fire fighters
- Public information about common fire hazards and use of smoke alarms
- Notification techniques and procedures
- Water pressure and availability

There are additional economic consequences related to this hazard. Urban fires and explosions may result in lost wages due to temporarily or permanently closed businesses, destruction and damage involving business and personal assets, loss of tax base, recovery costs, and lost investments in destroyed property.

The secondary effects of urban fire and explosion events relate to the ability of public, private, and nonprofit entities to provide post-incident relief. Human services agencies (community support programs, health and medical services, public assistance programs and social services) can be affected by urban fire and explosion events as well. Effects may consist of physical damage to facilities and equipment, disruption of emergency communications, loss of health and medical facilities and supplies, and an overwhelming load of victims who are suffering from the effects of urban fire, including the loss of their home or place of business.

Previous Occurrences

Because buildings exist anywhere people live and work, fires can occur at anytime and anyplace throughout the State. The frequency of structural fires depends on a wide range of factors. These factors include, but are not limited to, population or building density, building use, lack of fire codes, lack of enforcement when fire codes exist, fire safety practices (or lack thereof) by building occupants, lack of adequately equipped fire departments, and criminal intent related to arson.

Data on the frequency of structural fires is included in the National Fire Incident Reporting System Statistics (NFIRS) data provided by the MDFS (See **Table 3.91)**. This table also shows the change in fire statistics from year to year. Out of nearly 773 registered fire departments in the State, 398 are currently NFIRS user agencies. This translates to approximately 51 percent of departments are actively reporting data used to compile the NFIRS. Without 100 percent reporting, definitive conclusions are not possible; however, fire departments, law enforcement offices, and other agencies spend considerable manpower

and funding to respond to and investigate structural fires. Additional information on NFIRS can be found at http://dfs.dps.mo.gov/programs/resources/fire-incident-reporting-system.php.

Table 3.91. Missouri Structural and Urban Fire Statistics (2002-2016)

Year	Total Fires	Δ	Total Fire Dollar Loss	Δ	Fire Related Injuries	Δ	Fire Related Deaths	Δ
2002	19,749		$80,184,764		225		39	
2003	22,097	2,348	$68,193,344	($11,991,420)	272	47	48	9
2004	30,731	8,634	$103,699,511	$35,506,167	371	99	86	38
2005	24,182	-6,549	$99,120,053	($4,579,458)	319	-52	51	-35
2006	29,865	5,683	$1,238,056,662	$1,138,936,609	377	58	70	19
2007	27,324	-2,541	$4,156,015,816	$2,917,959,154	375	-2	70	0
2008	24,647	-2,677	$9,343,081,187	$5,187,065,371	12	-363	68	-2
2009	25,795	1,148	$2,399,531,780	($6,943,549,407)	287	275	57	-11
2010	24,785	-1,010	$6,132,675,694	$3,733,143,914	382	95	78	21
2011	22,429	-2,356	$127,256,829	($6,005,418,865)	288	-94	50	-28
2012	19,293	-3,136	$4,152,595,091	$4,025,338,262	317	29	44	-6
2013	18,970	-323	n/a	n/a	592	275	225	181
2014	18,970	0	n/a	n/a	592	0	225	0
2015	8,379	-10,591	**$1,137,228,082**	n/a	310	-282	46	-179
2016	18,970	10,591	n/a	n/a	592	282	225	179
AVG.	**22,412**		**$2,419,803,234**		**354**		**92**	

Source: NFIRS; data for 2013, 2014, and 2016 was not independently available, data provided is annualized. Data for 2017-2021 not available

Significant historical structural and urban fire events include the following:

- 1914 – Missouri Athletic Club fire in St. Louis, Missouri, killed 30 on March 9
- 1927 – Buckingham Hotel arson fire in St. Louis, Missouri, killed 7 on December 5
- 1952 – Nursing home fire in Hillsboro, Missouri, killed 20 on October 31
- 1956 – Reagan Nursing Home fire in Puxico, Missouri, killed 12 on July 31
- 1957 – Warrenton Nursing Home Fire in Warrenton, Missouri, killed 72 on February 17
- 1973 – National Archives Fire in St. Louis, Missouri, destroyed approximately 16-18 million official military personnel files
- 1979 – Nursing home fire in Farmington, Missouri, kills 26 on April 2

Probability of Future Hazard Events

According to the NFRIS data (2002-2016), the average annual number of structural and urban fires in Missouri is 22,412 causing estimated total annual average damages in the amount of $2.4 billion. Even with the limited data in the NFIRS statistics, the probability of structural fires is very high. Many factors contribute to the cause of structural and urban fires. Due to the various factors, urban areas in Missouri are considered at risk to one degree or another. Minor urban fires can be expected often in Missouri. Major fires will continue to occur several times a year, particularly in dense, urban areas with aging building stock. Similar to the various factors related to extent of the hazard, the probability of future

occurrences may decrease with the construction of new buildings to building codes that address fire prevention, detection, and extinguishments. Also, continued efforts to increase public awareness of the dangers of urban fires will help to mitigate injury, death, and property loss. The probability of future occurrence may increase in communities whose populations are growing and where new areas are developed.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard.

State Vulnerability Overview

Structural and urban fires are a daily occurrence throughout the State. According to the U.S Fire Administration, approximately 2.2 fatalities per 1,000 fires occur annually in Missouri, as well as numerous injuries affecting the lives of the victims, their families, and many others—especially those involved in fire and medical services. Unlike other disasters, structural fires are often insidious and despicable due to the prevalence of arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services, or the costs of supporting the criminal justice system.

The method used to determine vulnerability to structural and urban fires across Missouri was statistical analysis of data from several sources: HAZUS building exposure value data, housing density data from the U.S. Census, the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina, and structural fire incident data from the National Fire Incident Reporting System (NFIRS). The statewide percent of fire departments reporting to the NFIRS in 2015 was 60%. Although not all departments report to this system, it is the best available data from which to perform the statistical analysis. The incident types considered for structural and urban fire were those in the incident series 100-139. These incident types include all fires in the following categories:

1) Fires-other
2) Structure fire
3) Fire in mobile property used as a fixed structure
4) Mobile property (vehicle) fire

The fire incident types not considered for structural and urban fire are the considered wildfire incident types in the incident series 140-173 which include: natural vegetation fire, outside rubbish fire, special outside fire, and cultivated vegetation, crop fire.

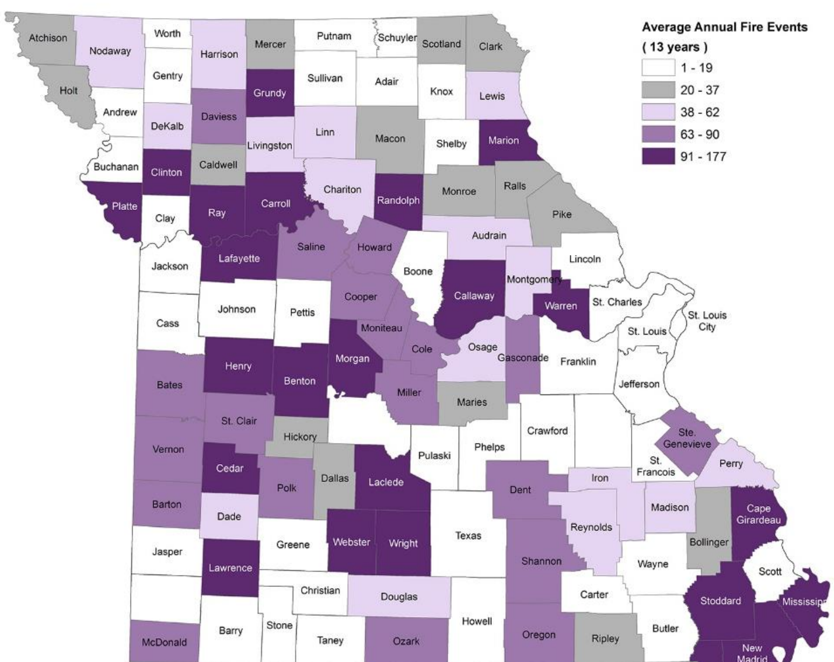
From the statistical data collected, six factors were considered in determining overall vulnerability to structural and urban fire as follows: housing density, building exposure, social vulnerability, likelihood of occurrence, annual property loss, and number of deaths/injuries. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Low-medium
3) Medium
4) Medium-high
5) High

All county-level statistical data tables are presented in Appendix A. **Figure 3.169** presents the average annual number of structural and urban fire events. **Figure 3.170** presents the number of deaths and injuries from structural and urban fire events. **Figure 3.171** that provides the overall vulnerability rating calculated by assigning an equal weight to each of the six contributing factors.

It should be noted that there are limiting factors inherent to the NFIRS source data. MDFS was not able to provide detailed county data for 2012-2016, only statewide summary data was available. Additionally, with 51-percent of Missouri Fire Departments reporting to the system, the available data does not present the complete hazard impact. Other factors to consider if data is available are the age of structures, building materials used, surrounding terrain and vegetation, occupancy status and status of regulatory oversight. These types of details are not consistently available on a statewide level. However, they may be more readily available at the local level.

Figure 3.169. Average Annual Structural and Urban Fire Events



Source: Missouri Department of Conservation, 2004 - 2016

Figure 3.170. Historical Number of Deaths and Injuries due to Structural and Urban Fires

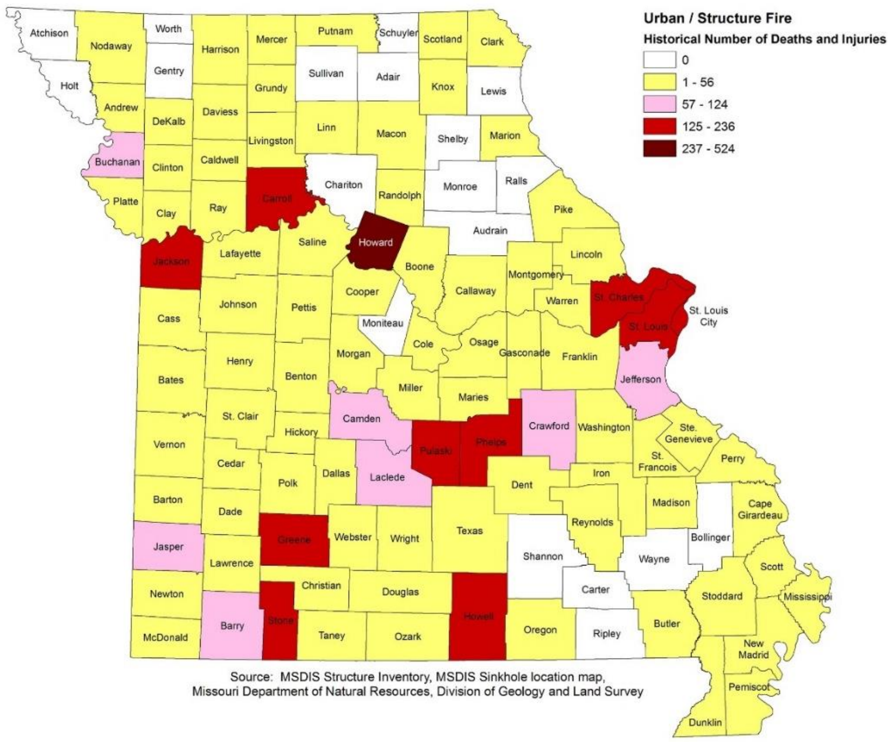
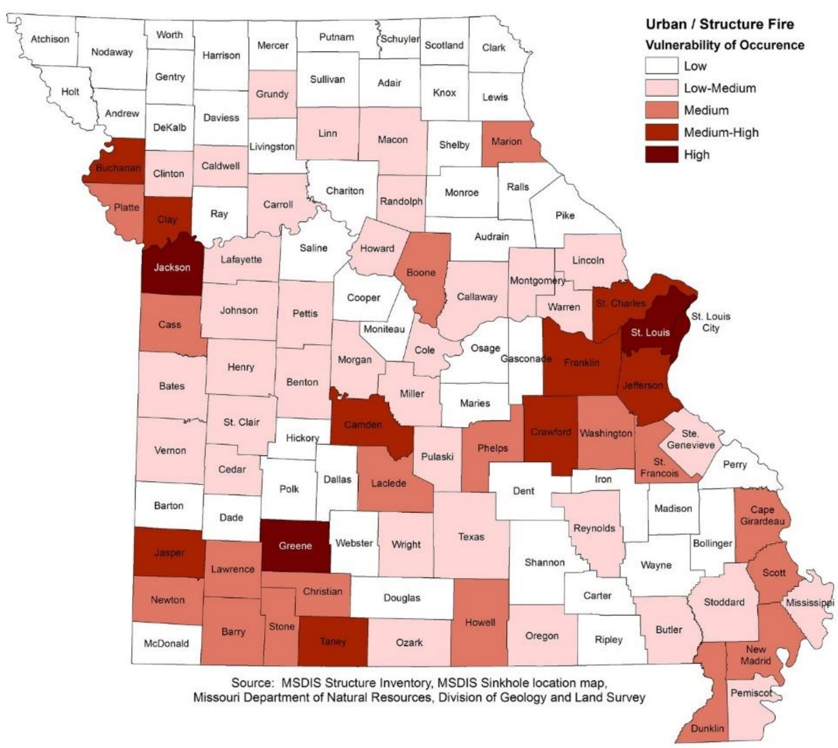


Figure 3.171. Vulnerability to Structural and Urban Fire



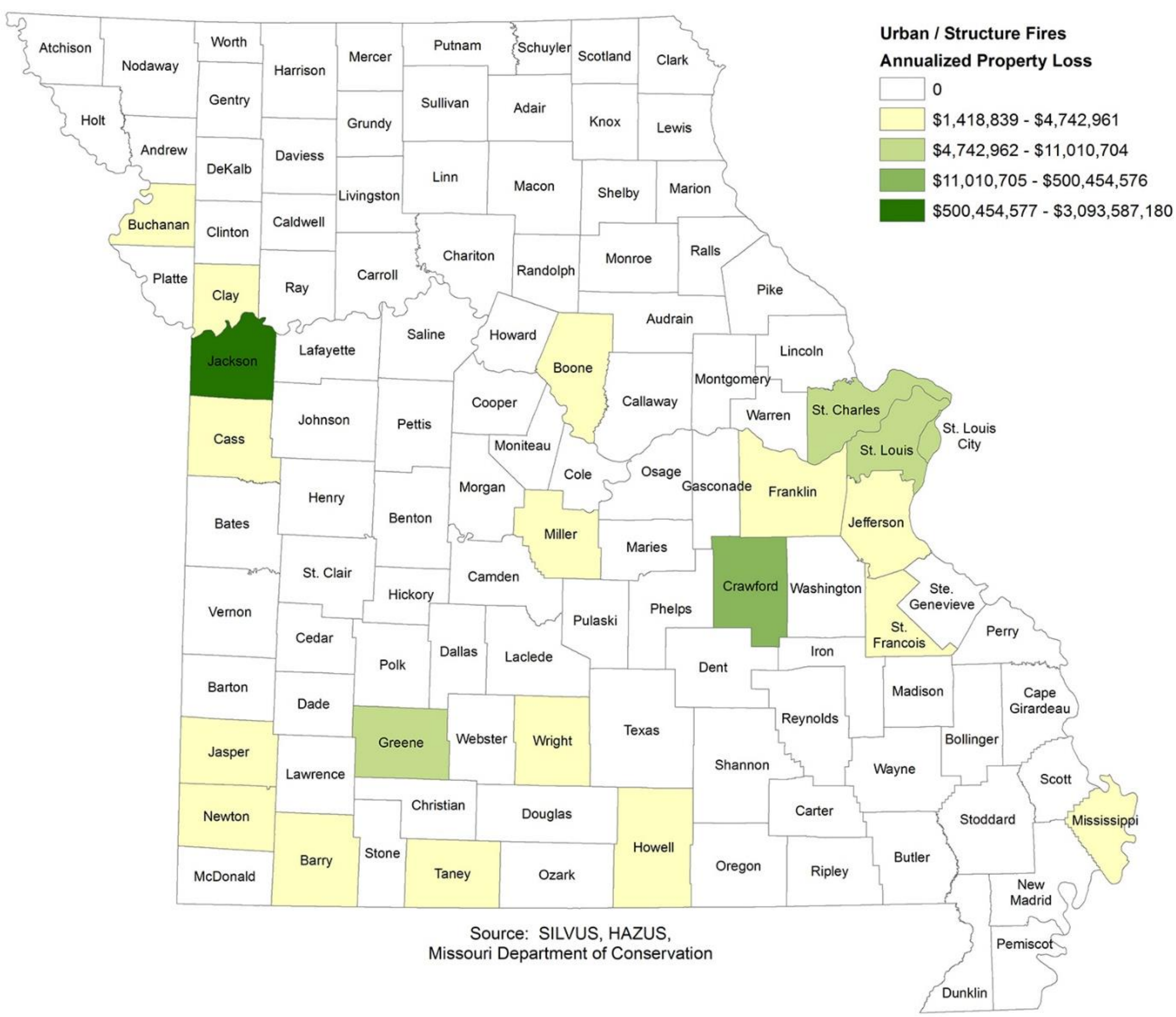
According to this vulnerability analysis, the following counties have a high vulnerability to structural and urban fires: Greene, Jackson, St. Louis, and the City of St. Louis.

State Estimates of Potential Losses

Structural and urban fires caused a total of 764 deaths and 2,403 injuries during the 5-year period from 2012-2016, data was not available for . This translates to an annualized occurrence of 153 deaths and 481 injuries statewide. With so many variables involved in death and injury occurrences, it is difficult to predict where future losses will occur.

To determine potential financial loss estimates to structural and urban fire in Missouri, the available historical loss data was annualized. In the case of this type of frequently occurring hazard, annualized historical loss data is considered to be the best resource for determining future potential losses. **.** Error! Reference source not found. provides the annualized total property losses for all counties in Missouri. **Figure 3.172** that follows provides this same information in map format.

Figure 3.172. Annualized Property Loss due to Structural and Urban Fire



Hazard Impact on Future Growth and Development

Of the top 10 counties vulnerable to structural and urban fire according to this statistical analysis methodology, the following also had population increases over from 2010-2015: Buchanan, Crawford, Davis, Dent, Harrison, Laclede, Nodaway and Pulaski.

Risk Summary

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. The greatest risk of interaction by fires with other hazards may involve damaging earthquakes. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural and urban fires.

Problem Statement:

Using Vulnerability to Structural and Urban Fire as the key indicator, the counties most at risk are Jackson, Greene and St. Louis City/County. Mitigation resources allocated to these counties would be the most beneficial.

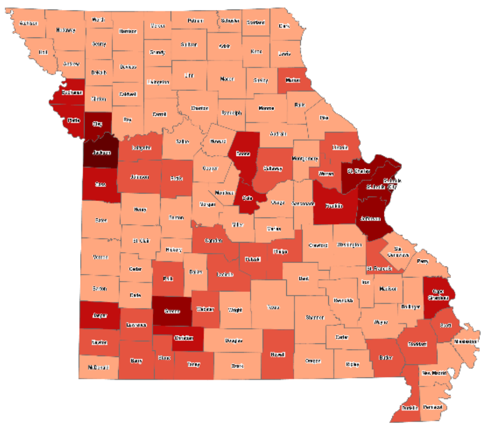
2023 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.3.22. Utilities (Interruptions and System Failures)

Description

Utility Interruptions and failures may involve electrical power, internet/telecommunications systems, natural gas, and public water and wastewater systems. These systems or combinations of these utility systems exist virtually throughout the State. Many utilities are localized and serve only one community, while other utilities serve a regional area. Disruption of any of these services could result from many of the natural or human-caused / technological hazards described in this plan.

Vulnerability



Extent/Range of Intensity

In many cases, utility interruptions are small, isolated events that are within the capabilities of the local utility to address. Due to long-range planning, regulation, and diligence of the utility operators, major interruptions resulting in a high degree of severity are few and far between. In some instances, utility outages and interruptions can impact a larger area and be for a prolonged period. Utility outages can also often be a cascading impact of a primary hazard such as flooding, severe thunderstorm, severe winter weather, and cyber disruptions.

Probability	Severity	Location
100%	Low	Statewide

State Vulnerability Overview

Utilities and infrastructure are vulnerable to damage from many natural hazards. Public health and safety and potential impacts on the economy are primary concerns with this hazard. Power and telephone lines are the most vulnerable infrastructure asset; but water supply, wastewater facilities and communications towers are also vulnerable. Typically, the events that cause the most damages are flood, lightning, winter storm, tornado, and wind storm. The electrical grid is vulnerable in periods of extreme heat when air conditioning use peaks. Underground utilities can also be damaged by expansive soils, erosion, earthquake and intentional or unintentional human actions.

Changing Future Conditions Considerations

Deteriorating infrastructure is a current nationwide problem that is likely to be exacerbated by changing future conditions. For example, existing stormwater systems were designed based on past conditions that are now changing; many systems may quickly become inadequate if storms continue to become more frequent and/or intense.

Risk Summary/Problem Statement

Severe weather causes more frequent local, and occasionally widespread, utility outages, however, manmade incidents, accidental or intentional, could significantly impact utility service. The earthquake threat to statewide and multi-state utilities is the greatest concern to the integrity and operability of Missouri’s utilities. Utility companies are generally well prepared to deal with day-to-day outages. Planning, regulation, mitigation, and mutual aid are all just a few tools available to reduce, speed recovery from, and prevent utility interruptions and failures.

Description/Location

Utility Interruptions and failures may involve electrical power, internet/telecommunications systems, natural gas, and public water and wastewater systems. These systems or combinations of these utility systems exist virtually throughout the State. Many utilities are localized and serve only one community, while other utilities serve a regional area.

Disruption of any of these services could result from many of the natural or human-caused / technological hazards described in this plan. In addition to a secondary or cascading impact from another primary hazard, utilities and infrastructure can fail because of geomagnetic storms, faulty equipment, lack of maintenance, degradation over time, or accidental damage such as damage to buried lines or pipes during excavation.

Geomagnetic storms can cripple communications that rely on the ionosphere. Many communications systems use the ionosphere to reflect radio signals over long distances. While TV and commercial radio stations are not typically affected by solar activity, ground-to-air, ship-to-shore, shortwave broadcast and amateur radio (mostly the bands below 30 MHz) are frequently disrupted. Users of these bandwidths include some military detention early warning systems, submarine detection systems, and aircraft. Solar disturbances also damage communications satellites. Increased solar ultraviolet emissions heat the earth’s upper atmosphere causing it to expand. The heated air rises and the density at the orbit of the satellites increases. This creates increased drag on the satellite which in turn causes the satellite to slow and change orbit slightly. Also, during a storm, the number and energy of electrons and ions increases. As a satellite travels through this environment, charge accumulates and can harm the satellite’s electrical systems. Damage to communications satellites can disrupt non-terrestrial telephone service, television, radio, and internet service.

Electric Power

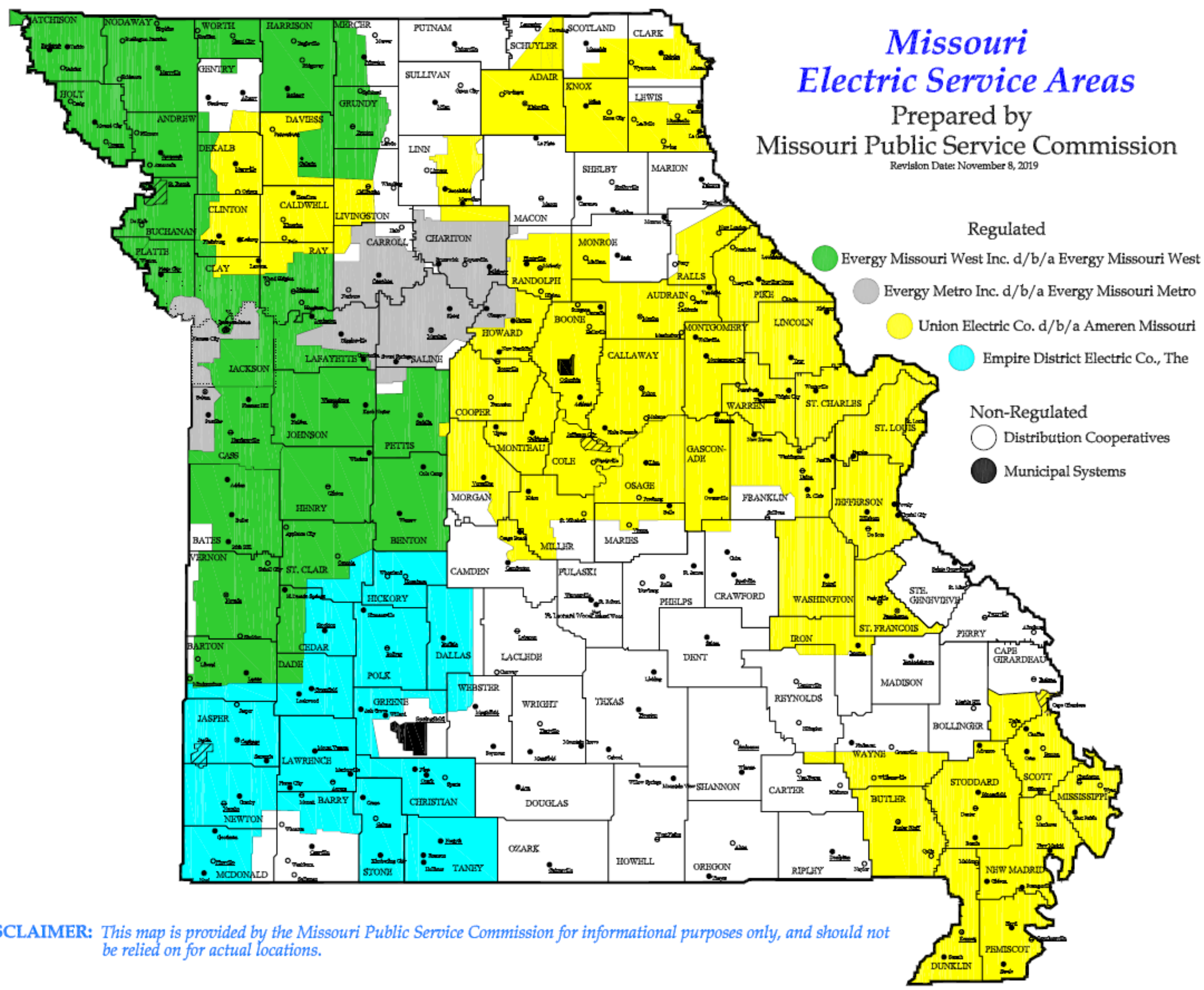
Disruption of electric power supply can be a cascading impact of several other hazards profiled in this plan including: flood, tornado, windstorm, and wither weather. These hazards can cause damage to power infrastructure. To a lesser extent, extreme temperatures, dam failure, levee failure, lightning, and terrorism could cause power disruption as well. Extreme heat can disrupt power supply when air conditioning use spikes during heat waves which can cause brownouts. Like floods, dam and levee failures can impact power infrastructure. Lightning strikes can damage substations and transformers, but is usually isolated to small areas of outage. Many forms of terrorism could impact power supply either by direct damage to infrastructure or through cyber-terrorism targeting power supply networks. Geomagnetic storms, faulty equipment, lack of maintenance, degradation over time, or accidental damage such as damage to buried power cables can also cause disruption to electric power. Electrical utilities in Missouri prepare for disasters and power outages by developing written plans to follow when events cause outages to customers. Power outages caused by severe weather have prompted the creation of tree-trimming plans to ensure above ground power lines are free of potential limbs that could fall on power lines and cause interruptions of power if knocked down. In addition, ongoing reviews of emergency plans and training for such events have been implemented. Many utilities also use emergency batteries or generators to provide back-up power for high priority equipment. After the 2002 ice storm that struck western and northern Missouri, an automated outage reporting system was created. The Public Service Commission also advised utility companies to provide feedback to customers that their outage report was recorded.

Electric service is provided in Missouri by the following providers:

- Evergy Missouri Metro (formerly Kansas City Power & Light)
- Evergy Missouri West
- Empire District Electric Company
- Union Electric Company d/b/a Ameren UE
- Distribution Cooperatives (electric cooperatives)
- Municipal Systems

Figure 3.173 provides Missouri Electric Service Areas.

Figure 3.173. Missouri Electric Service Areas



Source: Missouri Public Service Commission, https://psc.mo.gov/CMSInternetData/Electric/Missouri%20Electric%20Service%20Area%20Map%2011-8-19.pdf

Missouri's electric cooperatives are non-profit power suppliers owned by their members. Each is governed by a board of directors elected from among the membership. There are 40 distribution cooperatives which provide electricity to individual homes, farms, and businesses. Some of these co-ops are quite large while others may serve just one county. Missouri's smallest electric cooperative has just

over 2,000 member-owners while the largest has more than 40,000 members. In addition to the 40 distribution cooperatives, there are six transmission cooperatives and Associated Electric Cooperative, the wholesale power provider to the distribution and transmission cooperatives. These cooperatives contribute to a comprehensive hazard mitigation plan which contains information pertaining to all 47 of the state's electric cooperatives. Due to sensitive data relating to the power grid in the State, this plan is not available to the public.

Regardless of size, each electric cooperative operates in similar fashion. Each member-owner has one vote at an annual membership meeting at which bylaws are approved and board members are elected. The board members, each a member of the cooperative, set policy for the co-op to direct day to day operations. Missouri's electric distribution cooperatives buy wholesale power from Associated Electric Cooperative, headquartered in Springfield, Missouri. Like the local electric cooperatives, Associated Electric Cooperative operates on a not-for-profit basis and is owned by those who use the services it provides—in this case, Missouri's distribution and transmission cooperatives. Missouri's six transmission cooperatives deliver wholesale electricity from Associated to local distribution cooperatives over high-voltage transmission lines. For more information about specific cooperatives, visit the Association of Missouri Electric Cooperatives at http://www.amec.org.

Internet / Telecommunications

Internet and telecommunications infrastructure and service can be impacted by the same hazards that can impact electric power supply. Land line telephone lines often utilize the same poles as electric lines. So, when weather events such as windstorm or winter weather cause lines to break, both electricity and telephone services experience outages. With the increasing utilization of cellular telephones, hazard events such as tornadoes that can damage cellular repeaters can cause outages. In addition, during any hazard event, internet and telecommunications systems can become overwhelmed due to the surge in call usage/volume.

Vulnerability of buried telecommunications cables has always been a problem. Cables may be subject to accidental or intentional cuts. However, legislation and mitigation procedures have been taken to prevent such events. Missouri law provided for the creation of the "One Call" call center to locate and mark buried utilities when requested prior to any digging/excavating. Most Local Exchange Carriers have their facilities on record with One Call. Missouri Revised Statute Chapter 319, "underground Facility Safety and Damage Prevention Act" is the legislation governing requirements to have utilities identified prior to digging or excavation. Additional steps to prevent cutting of buried telecommunications cables include clearly marking cable routes with above ground pedestals and poles, as well as patrolling the routes by vehicle and air. In addition to these precautions, most companies have constructed fiber rings for the fiber optic routes to provide for continuity of service in the event of an accidental cut.

Since floods pose a threat to telephone service, most companies with buried cables in floodplains are replacing conventional telephone pedestals with flood resistant telephone pedestals, which protect the cables during floods of short duration.

In 1990, the Missouri Public Service Commission requested that all Local Exchange Carriers submit plans for disaster recovery. Every LEC in the state submitted a plan detailing practices and procedures for service restoration in the event of a disaster. Additionally, to mitigate damage of earthquakes or other disasters, the Local Exchange Carriers added bracing to their central offices for their switching equipment and batteries. Many companies have also obtained on-site generators or made contingency arrangements to acquire them in response to an outage.

Natural Gas

Primary hazards that can impact natural gas pipelines are earthquake, land subsidence, human error/digging accidents, infrastructure degradation, and acts of terrorism/vandalism. All natural gas system operators in the State operate under the jurisdiction of the Missouri Public Service Commission. These operators must comply with the commission's pipeline safety regulations which include emergency response procedures to pipeline emergencies and natural disasters. Natural gas operators have plans on file with the Missouri Public Service Commission. These include indexes of utilities and their locations in the State.

In 1989, Missouri House Bill 938 provided the commission with additional legal power to enforce the Pipeline Safety Regulations. In 1990, due in part to the Iben Browning earthquake projection, all utilities were mandated by the commission to develop natural disaster plans (to include potential impacts of earthquakes) and file the plans with the commission. The commission also developed its own plan to respond to a disaster causing an interruption or failure of a utility service. The Iben Browning earthquake projection created a new awareness for the necessity for such disaster response and recovery plans. Several natural gas companies have since stored emergency equipment and survival rations in protected locations. This also resulted in a new demand for excess flow and motion sensing valves on natural gas service lines. Operators also reviewed, updated or increased their mutual aid agreements with other utilities and contractors.

According to the Pipeline and Hazardous Materials Administration, in 2022, there were 52,630 miles of natural gas pipelines in Missouri as shown in the following table:

Table 3.92. Natural Gas Pipeline Miles by System Type

Type	Miles
Gas Distribution Mail Miles	28,471
Gas Distribution Service Miles	19,537
Gas Transmission	4,622
Gas Gathering	0
Total	**52,630**

Source: Pipeline and Hazardous Materials Administration, https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities

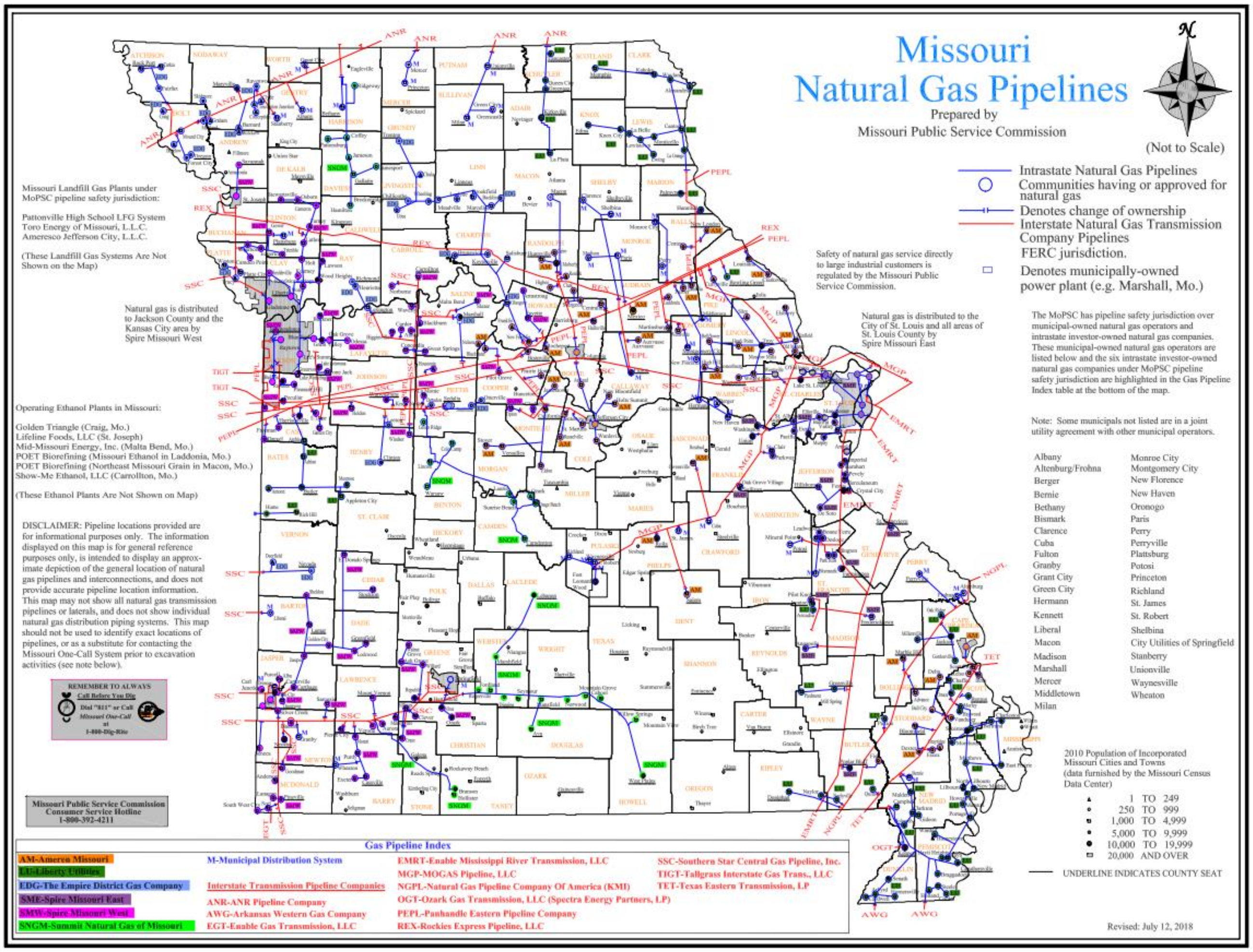
The distribution pipelines are operated by 50 different companies. Over 3,600 miles of Interstate transmission lines are operated by 12 companies and over 1,000 miles of intrastate transmission lines are operated by 13 companies. Missouri's natural gas pipelines are shown in **Figure 3.174**.

As discussed previously, Missouri law requires all owners and operators of underground pipeline facilities to participate in the One Call notification center. This participation provides for the location of underground pipelines after notification by the excavator and before any excavation begins.

Public Water and Wastewater Systems

The primary hazards that can impact water supply systems are: drought, flood, hazardous materials, and terrorism and any hazard impacting power supply. The primary hazard that impacts water systems is flood and other hazards impacting power supply. As with other infrastructure, these systems can also be impacted by accidental damage, lack of maintenance/degradation over time, and human error. **Table 3.93** provides the number of Public Water Intakes and Wastewater Treatment Facilities by county in Missouri.

Figure 3.174. Missouri Natural Gas Pipelines



Source: Missouri Public Service Commission,
https://psc.mo.gov/CMSInternetData/Gas/Missouri%20Natural%20Gas%20Pipeline%20Map%207-12-2018.pdf

Table 3.93. Public Water Intakes/Wells and Wastewater Treatment Facilities by County, 2017

County	Number of Public Water Intakes/Wells	Number of Wastewater Treatment Facilities
Adair	2	2
Andrew	1	4
Atchison	0	5
Audrain	0	6
Barry	0	13
Barton	1	3
Bates	13	9
Benton	0	6
Bollinger	0	1
Boone	0	22
Buchanan	2	2
Butler	1	7
Caldwell	2	11
Callaway	0	21
Camden	0	153
Cape Girardeau	1	36
Carroll	0	4
Carter	0	3
Cass	11	12
Cedar	0	5
Chariton	1	9
Christian	0	11
Clark	2	6
Clay	3	14
Clinton	1	8
Cole	1	21
Cooper	1	6
Crawford	0	3

County	Number of Public Water Intakes/Wells	Number of Wastewater Treatment Facilities
Dade	1	5
Dallas	0	2
Daviess	3	9
DeKalb	5	9
Dent	0	3
Douglas	0	1
Dunklin	0	8
Franklin	1	36
Gasconade	0	7
Gentry	3	3
Greene	4	5
Grundy	1	4
Harrison	7	7
Henry	3	8
Hickory	0	3
Holt	0	11
Howard	3	6
Howell	0	1
Iron	1	5
Jackson	2	13
Jasper	0	11
Jefferson	3	37
Johnson	1	15
Knox	4	4
Laclede	0	7
Lafayette	5	16
Lawrence	0	5
Lewis	4	7
Lincoln	0	23
Linn	6	11
Livingston	0	6
Macon	4	3
Madison	4	6
Maries	0	1
Marion	2	6
McDonald	0	6
Mercer	1	3
Miller	0	21
Mississippi	0	5
Moniteau	0	6
Monroe	2	5
Montgomery	4	5
Morgan	0	25
New Madrid	0	6

County	Number of Public Water Intakes/Wells	Number of Wastewater Treatment Facilities
Newton	2	6
Nodaway	3	22
Oregon	0	4
Osage	0	8
Ozark	0	2
Pemiscot	0	6
Perry	1	5
Pettis	1	18
Phelps	0	17
Pike	5	10
Platte	2	7
Polk	0	9
Pulaski	1	12
Putnam	2	4
Ralls	1	9
Randolph	3	10
Ray	1	8
Reynolds	1	4
Ripley	0	1
Saline	0	8
Schuyler	4	2
Scotland	2	1
Scott	0	11
Shannon	0	6
Shelby	4	4
St. Charles	1	21
St. Claire	0	5
St. Francis	0	12
St. Louis	7	19
St. Louis City	1	1
Ste. Genevieve	0	6
Stoddard	0	16
Stone	0	31
Sullivan	6	5
Taney	3	12
Texas	0	6
Vernon	0	5
Warren	0	14
Washington	1	10
Wayne	3	7
Webster	0	10
Worth	0	2
Wright	0	4
Totals	**172**	**1169**

Source: Missouri Department of Natural Resources

Extent /Range of Intensities

In many cases, utility interruptions are small, isolated events that are within the capabilities of the local utility to address. Therefore, the degree of severity of the day-to-day events may be considered low. Due to long-range planning, regulation, and diligence of the utility operators, major interruptions resulting in a high

degree of severity are few and far between. In some instances, utility outages and interruptions can impact a larger area and be for a prolonged period. Utility outages can also often be a cascading impact of a primary hazard such as flooding, severe thunderstorm, severe winter weather, and cyber disruptions.

Previous Occurrences

Because utilities exist everywhere in the State, damage to utilities may occur frequently. Causes of damage can range from a backhoe cutting a buried line, an accident involving a motor vehicle, a flood, a geomagnetic storm, or another hazard event. Many of these interruptions or failures go unreported and no comprehensive system is in place to capture historical outages. Therefore, limited information is available to develop statistical analysis of previous events for all utility types. For electric utility interruptions, Inside Energy has compiled a database of 15 years of power outages compiled from annual data available from the Department of Energy. **Table 3.94** provides the outages that included the State of Missouri.

Table 3.94. Power Outages in Missouri (2000-2021)

Event Description	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Respondent	Geographic Areas	Number of Customers Affected	Tags
System Operations	6/23/2021	3:47 PM	6/23/2021	4:44 PM	Unknown	Boone County, Missouri	0	N/A
System Operations	5/06/2021	5:00 PM	5/06/2021	5:15 PM	Unknown	Jasper County, Missouri	0	N/A
Severe Weather, Transmission Interruption	2/16/2021	6:10 AM	Unknown	Unknown	Unknown	Missouri	130	N/A
Severe Weather	2/16/2021	4:40 PM	2/20/2021	12:00 AM	Unknown	Missouri	Unknown	N/A
Severe Weather	2/15/2021	12:18 PM	2/15/2021	1:22 PM	Unknown	Missouri, Kansas	Unknown	N/A
Severe Weather	2/14/2021	6:00 PM	2/16/2021	10:00 PM	Unknown	Jasper County, Missouri	Unknown	N/A
Severe Weather	2/14/2021	7:05 PM	Unknown	Unknown	Unknown	Missouri, Kansas	Unknown	N/A
System Operations	1/15/2021	5:48 PM	1/15/2021	6:55 PM	Unknown	Missouri	0	N/A
System Operations	12/09/2020	1:20 PM	12/09/2020	2:30	Unknown	Missouri, Kansas	0	N/A
System Operations	11/18/2020	8:30 AM	11/18/2020	10:50 AM	Unknown	Jackson County, Missouri	0	N/A
Vandalism	10/03/2019	12:13 AM	10/03/2019	4:00 AM	Unknown	Reynolds County, Missouri	0	N/A
Physical Attack	7/20/2019	7:37 AM	7/20/2019	9:20 AM	Unknown	Boone County, Missouri	0	Suspicious Activity
Severe Weather	1/12/2019	11:30 AM	Unknown	Unknown	Unknown	Missouri, Nebraska	116,600	N/A
Severe Weather	1/12/2019	11:30 AM	1/13/2019	10:00 PM	Unknown	Jackson County, Missouri, Johnson County, Kansas	112,530	N/A
Vandalism	8/15/2018	12:00 AM	8/15/2018	1:00 AM	Unknown	Boone County, Missouri	0	N/A
Severe Weather	6/28/2018	6:36 PM	7/01/2018	7:00 AM	Unknown	Missouri, Illinois	112,000	N/A
Severe Weather	6/02/2018	5:00 AM	6/02/2018	11:00 AM	Unknown	Missouri Counties: Jackson, Clay, Platte, Andrew: Johnson County, Kansas	103,535	N/A
Severe Weather	7/23/2017	4:00 AM	Unknown	Unknown	Unknown	Missouri, Illinois	82,000	N/A
Severe Weather	7/22/2017	10:00 PM	Unknown	Unknown	Unknown	Missouri	115,000	N/A
Severe Weather	7/22/2017	10:00 PM	Unknown	Unknown	Unknown	Missouri	131,000	N/A
Severe Weather	7/22/2017	10:00 PM	7/23/2017	12:00 PM	Unknown	Missouri Counties: Clay, Jackson, Lafayette, Platte,	112,540	N/A

Event Description	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Respondent	Geographic Areas	Number of Customers Affected	Tags
						Kansas Counties: Johnson, Miami, Wyandotte		
Physical Attack	7/18/2017	4:03 AM	Unknown	Unknown	Unknown	Missouri	700	Actual Physical Attack
Severe Weather	5/19/2017	5:30 AM	Unknown	Unknown	Unknown	Missouri: St Louis County	70,696	N/A
Severe Weather	3/06/2017	8:00 PM	3/07/2017	1:00 AM	Unknown	Missouri Counties: Jackson, Platte, Cass, Lafayette, Chariton, Carrol, Clay, Johnson	97,734	N/A
Systems Operations	2/17/2017	4:32 AM	2/17/2017	5:02 AM	Unknown	Missouri, Arkansas, Oklahoma, Texas	0	N/A
Suspected Physical Attack	5/24/2016	8:00 AM	Unknown	Unknown	Unknown	Missouri	0	Vandalism
Suspected Physical Attack	5/14/2016	9:25 AM	5/15/2016	5:24 PM	Unknown	Missouri	0	Sabotage
Suspected Physical Attack	12/31/2015	11:00 AM	Unknown	Unknown	Unknown	Missouri	0	Sabotage
System Operations	12/10/2015	9:25 PM	12/10/2015	10:30 PM	Unknown	New Madrid County, Missouri	1	N/A
Severe Weather - Snow/Ice	2/20/2014	4:40 pm	2/21/2014	11:59 PM	Ameren Missouri	Missouri, Illinois	66,000	severe weather, winter storm
Physical Attack - Vandalism	1/21/2014	12:14 pm	1/21/2014	12:39 PM	Ameren Missouri	Missouri	Unknown	vandalism, physical
Severe Weather - Tornadoes	11/17/2013	12:35 pm	11/20/2013	11:00 AM	Ameren Missouri	Central Missouri, Central Illinois	200,000	severe weather, tornado
Physical Attack; Vandalism	8/29/2013	9:50 am	8/29/2013	9:50 AM	Empire District Electric Co	Joplin, Missouri	Unknown	vandalism, physical
Severe Weather - Thunderstorms	5/31/2013	7:30 pm	6/1/2013	8:00 PM	Ameren Missouri	St. Louis Metro Area Missouri	100,000	severe weather, thunderstorm
Severe Weather - Winter Storm Nemo	2/26/2013	1:00 pm	3/1/2013	10:00 AM	Associated Electric Coop, Inc	Northern Missouri	56,444	severe weather, winter storm
Severe Thunderstorms	6/27/2011	12:00 am	6/29/2011	1:00 AM	AMEREN	Illinois; Missouri	80,000	severe weather, thunderstorm
Severe Weather	5/23/2011	12:30 pm	5/25/2011	12:30 PM	Ameren	St. Louis County	70,000	severe weather
Severe Weather	5/22/2011	5:09 pm	5/31/2011	12:01 PM	Empire District Electric	Joplin, Sarcoxie, and Wentworth,	20,000	severe weather
Severe Weather	4/22/2011	9:00 pm	4/22/2011	11:00 PM	Ameren	Metro St. Louis area, Missouri	55,000	severe weather

Event Description	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Respondent	Geographic Areas	Number of Customers Affected	Tags
Severe Thunderstorm	5/8/2009	7:30 am	5/8/2009	9:00 AM	Empire District Electric Company	SW Missouri	83,000	severe weather, thunderstorm
Winter Storm	1/28/2009	12:10 am	1/30/2009	9:20 PM	Midwest ISO	East Central Missouri	1	severe weather, winter storm
Winter Storm	1/27/2009	11:00 am	1/30/2009	6:00 PM	Associated Electric Coop, Inc.	South Central and Southeast	62,500	severe weather, winter storm
Fire/Load Shedding	12/2/2008	4:30 am	12/2/2008	7:00 AM	Midwest ISO	St. Louis, Missouri	53,000	wild fire, load shedding
Hurricane Ike	9/14/2008	7:30 am	9/18/2008	3:00 PM	Ameren Corporation	Missouri and Illinois	107,000	severe weather, hurricane/tropical storm
Severe Thunderstorm	8/13/2007	1:30 am	8/14/2007	12:00 AM	Ameren Corporation	State of Missouri	63,000	severe weather, thunderstorm
Ice Storm	1/13/2007	5:00 am	1/19/2007	12:00 PM	Ameren Corporation	Missouri and Illinois	225,000	severe weather, winter storm
Ice Storm	11/30/2006	9:00 pm	12/9/2006	6:00 PM	Ameren Corporation	Missouri and Illinois	550,000	severe weather, winter storm
Severe Storms (3) (Many experienced multiple outages.)	7/19/2006	6:00 pm	7/31/2006	8:00 AM	Ameren Corporation	Greater St. Louis Metropolitan area (MO and IL)	700,000(peak) 2,500,000 (actual)	severe weather, storm
Ice Storm	1/30/2002	4:00 pm	2/10/2002	9:00 AM	Missouri Public Service	Missouri	95,000	severe weather, winter storm

Source: Inside Energy: http://insideenergy.org/2014/08/18/data-explore-15-years-of-power-outages/ , US Department of Defense: https://www.oe.netl.doe.gov/OE417_annual_summary.aspx

Narratives of additional notable previous occurrences of various utility interruptions/failures are provided below:

- On March 13, 1989, a geomagnetic storm caused the Hydro-Québec power grid to fail. On March 10, an explosion on the sun released a billion-ton cloud of gas that headed towards earth at a million miles per hour. The solar flare that followed the explosion caused short-wave radio interference immediately. The magnetic disturbance was so intense that it created electrical currents in the ground beneath North America. These currents found a weakness in the Québec power grid and millions of people were without power for 12 hours. The power outage closed schools and businesses, Dorval Airport and the Montreal Metro during morning rush hour. U.S. electrical utilities were also affected. There were 96 electrical utilities in New England interrupted while other reserves of electrical power were brought online. Across the United States, over 200 power grid problems were reported within minutes of the storm but none cased a blackout (NASA, 2009).
- During the flood of 1993, telecommunications companies proved their adaptability by using cellular service to replace wire line service in areas where service could not be restored in a timely manner. One local exchange company used a trailer with cellular pay phones where the land lines were interrupted. Another company temporarily replaced analog subscriber carrier service with site-based cellular service. Short-haul portable microwave was also used to replace copper lines lost during the flood.
- On January 30, 2002, a severe ice storm struck portions of western and northern Missouri leaving devastation and darkened homes and businesses. Many news articles referred to this ice storm as the worst in Missouri's history. During the ice storm, ice accumulated on any object that was at or below freezing, and the weight of the ice broke utility poles, conductors, tree limbs, and other objects that could not withstand the weight of the ice. Ice accumulations over an inch were reported in many areas. Many tree branches could not withstand the added weight of the ice and fell to the ground, striking whatever was in their path. Cars, homes, streets, properties, and electric power facilities were recipients of the falling trees and limbs. When the ice began to melt, the falling ice caused additional outages. Some electric customers experienced outages more than once during that period, as power was restored but interrupted again by falling limbs. At the peak of outages, over 400,000 customers were without power. Within three days, most of these customers were returned to service, but many customers in more heavily damaged areas were without power for over a week. Utilities affected by the ice storm quickly mobilized all their available crews and sought outside assistance. Work crews from 16 different states came to western Missouri to rapidly restore power to as many customers as possible.
- On July 19-20, 2006, severe storms with high winds and possible tornado activity struck St. Louis and the counties of St. Louis, Dent, Iron, Jefferson, Oregon, St. Charles, and Washington. Because of the storms, approximately 500,000 AmerenUE customers were without electrical power. Over 3,600 utility workers from AmerenUE and outlying utility companies were involved in restoration efforts, the largest in company history. High priority projects included restoring power to 14 nursing homes, cooling stations, hospitals, city services, and utility and fuel terminals. Compounding the power outage problems, a heat advisory with heat index values as high as 104 degrees Fahrenheit plagued recovery efforts for several weeks.
- In January 2009, over two-and one-half inches of snow covered most of the southeast portion of the state. Heavy ice accumulations caused over 3,800 AmerenUE transmission and distribution poles to break. Similar breakages were experienced by municipal and electric cooperative systems and

transmission operators. Because of the extent of damage, some locations were without power for up to three weeks.

- In January 2011, record amounts of snow that caused blizzard conditions across the state resulted in widespread power outages.
- Sunday, May 22, 2011, a devastating weather event struck Joplin, Missouri, continuing through the cities of Duquesne, Diamond, Granby, Sarcoxie and Wentworth. The National Weather Service identified the event as an EF-5 tornado with winds more than 200 miles per hour. The tornado took a direct route through the heart of Joplin's residential and retail district, resulting in hundreds of injuries, deaths and the loss of thousands of homes and businesses. In addition, the storm also affected electrical power, natural gas, water and communications services.
- July 13, 2016, Major power outages occurred across the St. Louis metro area due to powerful storms. At the height of the storm, winds were clocked as high as 7miles per hour. As a result, approximately 128,000 Missouri AmerenUE customers were without power.
- July 22, 2017, a significant severe weather event impacted the greater Kansas City Metro area. Strong winds blew down trees, damaging homes and downing powerlines, leaving over 100,000 people without power.
- June 2, 2018, several thunderstorms passed through northwest Missouri and into the southeastern portion of the state. 70-80 mph winds caused damage across the area. Over 100,000 residents lost power.
- The City of St. Louis Water Division routinely lists water mains that are out of service on their website. Between December 2021 and February 2022, there were five mains out of service. Information on estimated population impacted was not available (source: http://www.stlwater.com/wateroos.php).
- Like St. Louis, KC Water also provides water service issues and outages on their website (https://local.nixle.com/kcwater/). For the time period between May 2021 and March 2022, there were 28 alerts posted regarding water pressure reductions and boil orders.

Probability of Future Hazard Events

Because utilities exist throughout the State and are vulnerable to interruptions or failures and because of multiple primary, secondary/cascading hazards, there is a very high probability that utility failures can occur at any time or location throughout the state. In most cases, these are small isolated events well within the capabilities of the local utility to address. But, occasionally, utility interruptions/failures are widespread, relying on coordinated response efforts to restore function. As previously noted, Inside Energy compiled a list of 20 power outage events within Missouri over a 15-year period which calculates to a 100% probability.

Changing Future Conditions Considerations

Deteriorating infrastructure is a current nationwide problem that is likely to be exacerbated by changing future conditions. Higher future temperatures, for example, would increase the demand for cooling homes, businesses, and public buildings, placing greater stress on power systems.

Existing stormwater systems were designed based on past conditions that are now changing; many systems may quickly become inadequate if storms continue to become more frequent and/or intense. Communities should prepare for even greater stress on infrastructure systems that may already be outdated. Although

declining infrastructure is a serious problem, it also presents an opportunity to improve and integrate existing systems so that they serve communities better and more efficiently.

State Vulnerability Overview

Utilities and infrastructure are vulnerable to damage from many natural hazards. Public health and safety and potential impacts on the economy are primary concerns with this hazard. Power and telephone lines are the most vulnerable infrastructure asset; but water supply, wastewater facilities and communications towers are also vulnerable. Typically, the events that cause the most damages are flood, lightning, winter storm, tornado, and wind storm. The electrical grid is vulnerable in periods of extreme heat when air conditioning use peaks. Underground utilities can also be damaged by expansive soils, erosion, earthquake and intentional or unintentional human actions. The Missouri Underground Facility Safety and Damage Prevention Act helps (§§319.010 to 319.050, RSMo) prevent accidental damage of underground facilities. This statute makes it illegal to excavate without first giving notice and obtaining information concerning the possible locations of underground facilities.

State Estimates of Potential Losses

This hazard includes all utility infrastructure and facilities that could be impacted by one or more hazard events. Electrical blackouts and power surges can damage high tech equipment but generally do not cause structural damage. Descriptions of utility/infrastructure assets that could be impacted are discussed above under the “Description/Location” section.

Potential losses would include the cost of repair or replacement of damaged facilities and lost economic opportunities for businesses. Secondary effects of infrastructure failure could include burst water pipes in homes without electricity during winter storms and damage to equipment due to power surges in the electrical grid during blackouts. Public safety hazards include risk of electrocution from downed power lines and hazard events that affect the normal functioning of wastewater facilities. Loss of use estimates can be calculated using FEMA’s BCA Reference Guide Loss of Use Estimates (see **Table 3.95**). These figures represent the loss of service only and do not consider physical damages to utility equipment and infrastructure.

Table 3.95. FEMA Standard Values for Loss of Service for Utilities

Loss of Electric Power	**Cost of Complete Loss of Service**
Total Economic Impact	$148 per person per day
Loss of Potable Water Service	**Cost of Complete Loss of Service**
Total Economic Impact	$105 per person per day
Loss of Wastewater Service	**Cost of Complete Loss of Service**
Total Economic Impact	$49 per person per day

Source: FEMA BCA Unit 3 Guide, June 2019

The July 2016 power outages due to windstorms knocked out power to more than 128,000 St. Louis metro area residents. Some residents were without power for two days. Based on FEMA’s loss of use estimates above, the cost of one full day without power for 128,000 residents, would exceed $18.9 Million.

Table 3.96 provides loss of service estimates, in relation to the populations served, in Missouri by county. The loss of use for each utility is provided in the heading as the loss of use cost per person per day of loss. The estimated loss of use provided for each county in Missouri represents the loss of service of the indicated utility for one day for 10 percent of the population. In rural areas, the typical loss of use may be for a larger

percentage of the population for a longer time during weather extremes. This loss estimation does not consider the portion of the population that does not utilize public utilities such as rural areas that use well water and home-site septic systems.

Table 3.96. Potential Loss Estimates for Utility Failure

County	2019 ACS Population	Potentially Affected Population (10%)	Electric ($148)	Drinking Water ($105)	Wastewater Treatment ($49)
Adair	25,369	2,537	$375,461	$266,375	$124,308
Andrew	17,503	1,750	$259,044	$183,782	$85,765
Atchison	5,229	523	$77,389	$54,905	$25,622
Audrain	25,644	2,564	$379,531	$269,262	$125,656
Barry	35,530	3,553	$525,844	$373,065	$174,097
Barton	11,797	1,180	$174,596	$123,869	$57,805
Bates	16,296	1,630	$241,181	$171,108	$79,850
Benton	19,107	1,911	$282,784	$200,624	$93,624
Bollinger	12,225	1,223	$180,930	$128,363	$59,903
Boone	177,651	17,765	$2,629,235	$1,865,336	$870,490
Buchanan	88,460	8,846	$1,309,208	$928,830	$433,454
Butler	42,656	4,266	$631,309	$447,888	$209,014
Caldwell	9,039	904	$133,777	$94,910	$44,291
Callaway	44,889	4,489	$664,357	$471,335	$219,956
Camden	45,466	4,547	$672,897	$477,393	$222,783
Cape Girardeau	78,491	7,849	$1,161,667	$824,156	$384,606
Carroll	8,781	878	$129,959	$92,201	$43,027
Carter	6,147	615	$90,976	$64,544	$30,120
Cass	103,597	10,360	$1,533,236	$1,087,769	$507,625
Cedar	14,043	1,404	$207,836	$147,452	$68,811
Chariton	7,483	748	$110,748	$78,572	$36,667
Christian	85,658	8,566	$1,267,738	$899,409	$419,724
Clark	6,779	678	$100,329	$71,180	$33,217
Clay	242,516	24,252	$3,589,237	$2,546,418	$1,188,328
Clinton	20,500	2,050	$303,400	$215,250	$100,450
Cole	76,723	7,672	$1,135,500	$805,592	$375,943
Cooper	17,660	1,766	$261,368	$185,430	$86,534
Crawford	24,154	2,415	$357,479	$253,617	$118,355
Dade	7,578	758	$112,154	$79,569	$37,132
Dallas	16,617	1,662	$245,932	$174,479	$81,423
Daviess	8,295	830	$122,766	$87,098	$40,646
DeKalb	12,526	1,253	$185,385	$131,523	$61,377
Dent	15,545	1,555	$230,066	$163,223	$76,171
Douglas	13,306	1,331	$196,929	$139,713	$65,199
Dunklin	30,027	3,003	$444,400	$315,284	$147,132
Franklin	103,191	10,319	$1,527,227	$1,083,506	$505,636
Gasconade	14,711	1,471	$217,723	$154,466	$72,084
Gentry	6,616	662	$97,917	$69,468	$32,418
Greene	289,756	28,976	$4,288,389	$3,042,438	$1,419,804
Grundy	9,992	999	$147,882	$104,916	$48,961
Harrison	8,491	849	$125,667	$89,156	$41,606
Henry	21,735	2,174	$321,678	$228,218	$106,502
Hickory	9,404	940	$139,179	$98,742	$46,080
Holt	4,432	443	$65,594	$46,536	$21,717
Howard	10,058	1,006	$148,858	$105,609	$49,284
Howell	40,104	4,010	$593,539	$421,092	$196,510
Iron	10,164	1,016	$150,427	$106,722	$49,804
Jackson	696,216	69,622	$10,303,997	$7,310,268	$3,411,458

County	2019 ACS Population	Potentially Affected Population (10%)	Electric ($148)	Drinking Water ($105)	Wastewater Treatment ($49)
Jasper	119,920	11,992	$1,774,816	$1,259,160	$587,608
Jefferson	223,951	22,395	$3,314,475	$2,351,486	$1,097,360
Johnson	53,682	5,368	$794,494	$563,661	$263,042
Knox	3,947	395	$58,416	$41,444	$19,340
Laclede	35,531	3,553	$525,859	$373,076	$174,102
Lafayette	32,597	3,260	$482,436	$342,269	$159,725
Lawrence	38,204	3,820	$565,419	$401,142	$187,200
Lewis	9,955	996	$147,334	$104,528	$48,780
Lincoln	56,477	5,648	$835,860	$593,009	$276,737
Linn	12,113	1,211	$179,272	$127,187	$59,354
Livingston	15,126	1,513	$223,865	$158,823	$74,117
Macon	15,199	1,520	$224,945	$159,590	$74,475
Madison	28,608	2,861	$423,398	$300,384	$140,179
Maries	8,803	880	$130,284	$92,432	$43,135
Marion	28,608	2,861	$423,398	$300,384	$140,179
McDonald	22,782	2,278	$337,174	$239,211	$111,632
Mercer	3,644	364	$53,931	$38,262	$17,856
Miller	25,201	2,520	$372,975	$264,611	$123,485
Mississippi	13,574	1,357	$200,895	$142,527	$66,513
Moniteau	16,046	1,605	$237,481	$168,483	$78,625
Monroe	8,629	863	$127,709	$90,605	$42,282
Montgomery	11,487	1,149	$170,008	$120,614	$56,286
Morgan	20,271	2,027	$300,011	$212,846	$99,328
New Madrid	17,560	1,756	$259,888	$184,380	$86,044
Newton	58,180	5,818	$861,064	$610,890	$285,082
Nodaway	22,359	2,236	$330,913	$234,770	$109,559
Oregon	10,647	1,065	$157,576	$111,794	$52,170
Osage	13,615	1,362	$201,502	$142,958	$66,714
Ozark	9,207	921	$136,264	$96,674	$45,114
Pemiscot	16,663	1,666	$246,612	$174,962	$81,649
Perry	19,191	1,919	$284,027	$201,506	$94,036
Pettis	42,355	4,236	$626,854	$444,728	$207,540
Phelps	44,630	4,463	$660,524	$468,615	$218,687
Pike	18,455	1,846	$273,134	$193,778	$90,430
Platte	100,682	10,068	$1,490,094	$1,057,161	$493,342
Polk	31,748	3,175	$469,870	$333,354	$155,565
Pulaski	52,425	5,243	$775,890	$550,463	$256,883
Putnam	4,781	478	$70,759	$50,201	$23,427
Ralls	10,234	1,023	$151,463	$107,457	$50,147
Randolph	24,878	2,488	$368,194	$261,219	$121,902
Ray	22,875	2,288	$338,550	$240,188	$112,088
Reynolds	6,290	629	$93,092	$66,045	$30,821
Ripley	13,567	1,357	$200,792	$142,454	$66,478
Saline	22,976	2,298	$340,045	$241,248	$112,582
Schuyler	4,555	456	$67,414	$47,828	$22,320
Scotland	4,902	490	$72,550	$51,471	$24,020
Scott	38,633	3,863	$571,768	$405,647	$189,302
Shannon	8,217	822	$121,612	$86,279	$40,263
Shelby	6,013	601	$88,992	$63,137	$29,464
St. Charles	394,290	39,429	$5,835,492	$4,140,045	$1,932,021
St. Clair	9,370	937	$138,676	$98,385	$45,913
St. Francois	66,643	6,664	$986,316	$699,752	$326,551
St. Louis	996,919	99,692	$14,754,401	$10,467,650	$4,884,903
St. Louis city	308,174	30,817	$4,560,975	$3,235,827	$1,510,053

County	2019 ACS Population	Potentially Affected Population (10%)	Electric ($148)	Drinking Water ($105)	Wastewater Treatment ($49)
Ste. Genevieve	17,848	1,785	$264,150	$187,404	$87,455
Stoddard	29,377	2,938	$434,780	$308,459	$143,947
Stone	31,615	3,162	$467,902	$331,958	$154,914
Sullivan	6,247	625	$92,456	$65,594	$30,610
Taney	55,114	5,511	$815,687	$578,697	$270,059
Texas	25,604	2,560	$378,939	$268,842	$125,460
Vernon	20,595	2,060	$304,806	$216,248	$100,916
Warren	34,453	3,445	$509,904	$361,757	$168,820
Washington	24,860	2,486	$367,928	$261,030	$121,814
Wayne	13,195	1,320	$195,286	$138,548	$64,656
Webster	38,655	3,866	$572,094	$405,878	$189,410
Worth	2,027	203	$30,000	$21,284	$9,932
Wright	18,203	1,820	$269,404	$191,132	$89,195

Source: FEMA BCA Unit 3 Guide, June 2019; U.S. Census Bureau 5-year American Community Survey, 2019

Hazard Impact on Future Growth and Development

Future development can increase vulnerability to this hazard by placing additional strains on existing infrastructure and by increasing the size and thus the exposure of infrastructure networks. In addition, utility and infrastructure development and expansion should be minimized or mitigated in known hazard areas to ensure the vulnerability to this hazard is not increased as a secondary impact to other hazard events.

Risk Summary

Utility companies are generally well prepared to deal with day-to-day outages. The earthquake threat to statewide and multi-state utilities is the greatest concern to the integrity and operability of Missouri's utilities. Severe weather causes more frequent local, and occasionally widespread, utility outages. Manmade incidents, accidental or intentional, could significantly impact utility service. Geomagnetic storms could disrupt communications and affect utility services. Planning, regulation, mitigation, and mutual aid are all just a few tools available to reduce, speed recovery from, and prevent utility interruptions and failures.

Utilities are often dispersed over a wide area, and many have facilities located throughout their service area. For example, many electric companies have multiple generating facilities which can redistribute power via transmission lines as they are connected to load stations. Therefore, power can be redistributed, if needed, so that power is lost to as limited an area as possible. Many water companies have some type of back-up systems such as water impoundments, other deep wells, or hook-up arrangements with other water companies. Similar switching and rerouting capabilities may exist with communications and natural gas utilities.

Although there are capabilities in place to minimize disruptions and restore outages as quickly as possible, risk remains for extended outages. As societies' reliance on power and communications continues to escalate, the extent of disruptions escalates as well.

Problem Statement:

Using the Potentially Affected Population from **Table 3.96** as the key indicator for Utility Disruptions, the most at-risk counties are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper, and Franklin Counties. Mitigation efforts and dollars focused on these counties first would be beneficial.

2023 risk assessment data and mapping are available through the Missouri Hazard Mitigation Viewer: https://bit.ly/MoHazardMitigationPlanViewer2023.

3.4. Integration of Local Plans: Vulnerability and Loss Estimates

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii): [The state risk assessment shall include] An overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events.

Requirement §201.4(c)(2)(iii): [The state risk assessment shall include] An overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment.

As of September 2022, there were 107 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. For the State Plan Update, the local plans listed above were reviewed to better understand how counties have approached risk assessments and what were identified as their greatest vulnerabilities. This review assists in comparing losses across the State and develop new mitigation actions to assist local communities.

3.4.1. Overview and Analysis of Local Plan Hazard Assessments

It is important in understanding what types of hazards are assessed at the local level. This assessment helps gauge whether counties are assessing the same hazards at the local level as those addressed by the State. A review of the local plans indicates that most local-level plans are addressing many of the same natural hazards. However, the analysis also revealed that most county-level plans did not include manmade hazards in their analysis, but rather focused on the natural hazards.

While the majority of plans did not cover manmade hazards, 20 counties analyzed pandemic hazards, likely due to the emergence of COVID 19. In the 2018 plan review of local plans, the analysis found that only 19 counties covered levee failure. The current review found that most plans (71) analyze levee failure separate from flood. Similarly, there has been a significant increase in the number of plans that cover land subsidence and sinkholes (98). To better determine areas of the State that are potentially impacted by both manmade and natural hazards, see the Human Caused/Tech Hazards sections covered in **Section 3.2.2**. **Table 3.97** shows each county and the hazards analyzed in the local plans. It should be noted that lightning is addressed as a separate hazard in **Section 3.3.8**, however lightning is analyzed under the thunderstorm hazard profile in this State Plan update.

Table 3.97. Hazards Analyzed in Local Plans

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Flooding	Extreme Heat	Landslide/Land Subsidence	Levee Failure	Lightning	Severe Winter Weather	Thunderstorms	Tornadoes	Other Hazards Addressed
Adair	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
AMEC MO*	X		X	X	X		X	X	X	X	X	X	
Andrew	X	X	X	X	X	X	X	X	X	X	X	X	
Atchison	X	X	X	X	X	X		X	X	X	X	X	
Audrain	X	X	X	X	X	X	X		X	X	X	X	
Barry	X	X	X	X	X	X	X		X	X	X	X	
Barton	X	X	X	X	X	X			X	X	X	X	
Bates	X	X	X	X	X	X	X	X	X	X	X	X	
Benton	X	X	X	X	X	X		X	X	X	X	X	Pandemic
Bollinger	X	X	X	X	X	X	X	X	X	X	X	X	
Boone	X	X	X	X	X	X	X	X	X	X	X	X	Public Health Emergency, Hazardous Materials Release, Transportation Incident, Nuclear Incident, Utility Service Disruption, Cyber Attack, Unwanted Intruder/Active Shooter, Terrorism, Civil Disorder, Mass Casualty/Fatality Event
Buchanan	X	X	X	X	X	X	X	X	X	X	X	X	Public Health Emergencies/Environmental Issues
Butler	X	X	X	X	X	X	X	X	X	X	X	X	
Caldwell	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Callaway	X	X	X	X	X	X		X		X	X	X	Hailstorm. Windstorm
Camden	X	X	X	X	X	X	X		X	X	X	X	
Cape Girardeau	X	X	X	X	X	X	X	X	X	X	X	X	
Carroll	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
Carter	X	X	X	X	X	X	X		X	X	X	X	

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Flooding	Extreme Heat	Landslide/Land Subsidence	Levee Failure	Lightning	Severe Winter Weather	Thunderstorms	Tornadoes	Other Hazards Addressed
Cass	X	X			X	X		X	X	X	X	X	
Cedar	X	X	X	X	X	X	X	X	X	X	X	X	
Chariton	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
Christian	X	X	X	X	X	X	X		X	X	X	X	
Clark	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
Clay	X	X			X	X		X	X	X	X	X	
Clinton	X	X	X	X	X	X	X	X	X	X	X	X	
Cole	X	X	X	X	X	X	X	X	X	X	X	X	Public Health Emergency, Hazardous Materials Release, Transportation Incident, Nuclear Incident, Utility Service Disruption, Telecommunications Disruption, Cyber Attack, Unwanted Intruder/Active Shooter, Terrorism, Civil Disorder, Mass Casualty/Fatality Event
Cooper	X	X	X	X	X	X	X	X	X	X	X	X	
Crawford	X	X	X	X	X	X	X		X	X	X	X	
Dade	X	X	X	X	X	X	X		X	X	X	X	
Dallas	X	X	X	X	X	X	X		X	X	X	X	
Daviess	X	X	X	X	X	X	X		X	X	X	X	Pandemic
DeKalb	X	X	X	X	X	X	X	X	X	X	X	X	
Dent	X	X	X	X	X	X	X		X	X	X	X	
Douglas	X	X	X	X	X	X	X		X	X	X	X	
Dunklin	X	X	X	X	X	X	X	X	X	X	X	X	
Franklin	X	X	X	X	X	X	X	X	X	X	X	X	
Gasconade	X	X	X	X	X	X	X	X	X	X	X	X	
Gentry	X	X	X	X	X	X	X	X	X	X	X	X	

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Flooding	Extreme Heat	Landslide/Land Subsidence	Levee Failure	Lightning	Severe Winter Weather	Thunderstorms	Tornadoes	Other Hazards Addressed
Greene	X	X	X	X	X	X	X		X	X	X	X	Airplane Crash, Cave/Mine Collapse, Hazardous Materials, Power Failure, Train Derailment, Biological, Chemical, Civil Unrest, Cyber, Nuclear, Radiological, Sabotage, Targeted Violence, Waste, Animal Disease, Communicable Disease
Grundy	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Harrison	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Henry	X	X	X	X	X	X	X	X	X	X	X	X	
Hickory	X	X	X	X	X	X	X	X	X	X	X	X	
Holt	X	X	X	X	X	X		X	X	X	X	X	
Howard	X	X	X	X	X	X	X	X		X	X	X	
Howell	X	X	X	X	X	X	X		X	X	X	X	
Iron	X	X	X	X	X	X	X	X	X	X	X	X	
Jackson	X	X			X	X		X	X	X	X	X	
Jasper	X	X	X	X	X	X	X	X	X	X	X	X	
Jefferson	X	X	X	X	X	X	X	X	X	X	X	X	
Johnson	X	X	X	X	X	X	X	X	X	X	X	X	
Knox	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Laclede	X	X	X	X	X	X	X		X	X	X	X	
Lafayette	X	X	X	X	X	X	X	X	X	X	X	X	
Lawrence	X	X	X	X	X	X	X		X	X	X	X	
Lewis	X	X	X	X	X	X		X	X	X	X	X	CBRNE Attack, Civil Disorder, Cyber Disruption, Hazardous Materials Release, Mass Transportation Incident, Public Health Emergencies/Environmental Issues, Special Events, Terrorism, Utility Disruption/Failure, EMP

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Flooding	Extreme Heat	Landslide/Land Subsidence	Levee Failure	Lightning	Severe Winter Weather	Thunderstorms	Tornadoes	Other Hazards Addressed
Lincoln	X	X	X	X	X	X	X	X	X	X	X	X	Hazardous Materials Release, Terrorism, Transportation Disruption, Utilities Disruption
Linn	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Livingston	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Macon	X	X	X	X	X	X	X		X	X	X	X	
Madison	X	X	X	X	X	X	X	X	X	X	X	X	
Maries	X	X	X	X	X	X	X		X	X	X	X	
Marion	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
McDonald	X	X	X	X	X	X	X		X	X	X	X	
Mercer	X	X	X	X	X	X			X	X	X	X	CBRNE attack
Miller	X	X	X	X	X	X	X	X	X	X	X	X	
Mississippi	X	X	X	X	X	X	X	X	X	X	X	X	
Moniteau	X	X	X	X	X	X	X	X	X	X	X	X	
Monroe	X	X	X	X	X	X	X	X	X	X	X	X	
Montgomery	X	X	X	X	X	X	X	X	X	X	X	X	Hazardous Materials, Nuclear Power Plant, Terrorism, Transportation Disruption, Utilities Disruption
Morgan	X	X	X	X	X	X	X	X	X	X	X	X	
New Madrid		X	X		X	X		X	X	X	X	X	
Newton	X	X	X	X	X	X	X	X	X	X	X	X	
Nodaway	X	X	X	X	X	X		X	X	X	X	X	
Oregon	X	X	X	X	X	X	X		X	X	X	X	
Osage	X	X	X	X	X	X	X	X	X	X	X	X	
Ozark	X	X	X	X	X	X	X		X	X	X	X	

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Flooding	Extreme Heat	Landslide/Land Subsidence	Levee Failure	Lightning	Severe Winter Weather	Thunderstorms	Tornadoes	Other Hazards Addressed
Pemiscot		X	X		X	X		X	X	X	X	X	
Perry	X	X	X	X	X	X	X	X	X	X	X	X	
Pettis	X	X	X	X	X	X	X	X	X	X	X	X	
Phelps	X	X	X	X	X	X	X		X	X	X	X	
Pike	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
Platte	X	X			X	X		X	X	X	X	X	
Polk	X	X	X	X	X	X	X		X	X	X	X	
Pulaski	X	X	X	X	X	X	X		X	X	X	X	
Putnam	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Ralls	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
Randolph	X	X	X	X	X	X	X	X	X	X	X	X	
Ray	X	X			X	X		X	X	X	X	X	
Reynolds	X	X	X	X	X	X	X		X	X	X	X	
Ripley	X	X	X	X	X	X	X	X	X	X	X	X	
Saline	X	X	X	X	X	X	X	X	X	X	X	X	
Schuyler	X	X	X	X	X	X	X	X	X	X	X	X	Pandemic
Scotland	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Scott	X	X	X	X	X	X	X	X	X	X	X	X	
Shannon	X	X	X	X	X	X	X		X	X	X	X	
Shelby	X	X	X	X	X	X	X	X	X	X	X	X	
St. Charles	X	X	X	X	X	X	X	X	X	X	X	X	
St. Clair	X	X	X	X	X	X			X	X	X	X	Pandemic

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Flooding	Extreme Heat	Landslide/Land Subsidence	Levee Failure	Lightning	Severe Winter Weather	Thunderstorms	Tornadoes	Other Hazards Addressed
St. Francois	X	X	X	X	X	X	X	X	X	X	X	X	
St. Louis	X	X	X	X	X	X	X	X	X	X	X	X	
St. Louis City	X	X	X	X	X	X	X	X	X	X	X	X	
Ste. Genevieve	X	X	X	X	X	X	X	X	X	X	X	X	
Stoddard	X	X	X	X	X	X	X	X	X	X	X	X	
Stone	X	X	X	X	X	X	X		X	X	X	X	
Sullivan	X	X	X	X	X	X	X		X	X	X	X	Pandemic
Taney	X	X	X	X	X	X	X		X	X	X	X	
Texas	X	X	X	X	X	X	X		X	X	X	X	
Vernon	X	X	X	X	X	X	X	X	X	X	X	X	
Warren	X	X	X	X	X	X		X	X	X	X	X	Hazardous Materials Release, Nuclear Power Plant, Terrorism, Transportation Disruption, Utilities Disruption
Washington	X	X	X	X	X	X	X		X	X	X	X	
Wayne	X	X	X	X	X	X	X		X	X	X	X	
Webster	X	X	X	X	X	X	X		X	X	X	X	
Worth	X	X	X	X	X	X		X	X	X	X	X	
Wright	X	X	X	X	X	X	X		X	X	X	X	

*AMEC MO: Multi-Jurisdictional Hazard Mitigation plan for Missouri's Elective Cooperatives (Not a county plan)

3.4.2. Overview and Analysis of Local Plan Potential Loss Estimates

The local plans' vulnerability assessments were reviewed to understand how counties addressed hazard loss estimates. The review examined whether counties performed their own analysis using local data and methodology, if they used the estimates provided in the State Hazard Mitigation Plan (HMP), or a combination of both local and state loss estimates. A summary of the counties' loss estimate approach for natural hazards can be found in **Table 3.98**. The table shows the number of counties that used the loss estimate analysis from the State HMP, a local analysis, or a combination of both state and local analysis of loss.

The incorporation of the State HMP data and loss estimate analysis varied among counties and hazards. The State HMP evaluated most hazards at the county level and used Hazus software, GIS analysis, and past occurrences to estimate losses. Many county-level plans included maps and direct loss estimate data from the State HMP. This analysis was adequate for many local plans, especially for more regional hazards. Additionally, not every county has the capability to perform an additional in-depth analysis. Some plans copied direct tables and maps from the State plan, while others supplemented State analysis with other data and risk assessment approaches. With the exception of Benton County, every plan, to some extent, incorporated State HMP data and/or analysis in the vulnerability assessment.

For hazards like levee and dam failure, that occur at a more localized level, most counties analyzed loss estimates using county and local data and a methodology different from the state's approach. For the majority of counties, loss estimates for thunderstorms and lightning were also evaluated using a local approach. Local loss estimates incorporated more specific county and local-level qualitative and quantitative data. Some local plans gathered information via data collection questionnaires and used datasets and parcel data from respective jurisdictions.

Table 3.98. Local Plan Approach to Loss Estimate Analysis

Hazard	State	Local	Combination (State & Local)
Dam Failure	41	68	4
Drought	60	50	5
Earthquake	80	29	1
Extreme Heat	58	54	3
Fires (structural/urban/wild)	61	46	-
Flood	61	54	-
Land Subsidence/Sinkholes	44	52	-
Levee Failure	10	60	-
Severe Winter Weather	57	47	10
Thunderstorms	32	79	4
Lightning	32	79	3
Tornado	64	37	14

3.4.3. Overview of Local Plan Vulnerability Problem Statements

All local county plans, with the exception of a few, incorporated problem statements that summarize key vulnerabilities, issues and takeaways for each hazard analyzed in the plans. Most local plans developed their own unique problem statements that referenced past occurrences, assets at risk, vulnerable populations, and proposed mitigation actions and projects. The problem statements vary depending on the assessed hazard and the unique challenges facing each county. Some plans have specific problem statements noting jurisdictions with higher risks, specific loss estimate data, and discuss specific mitigation measures. Others include brief risk summaries and general suggestions about where to focus mitigation actions. Despite varying degrees of detail, there are many commonalities between the problem statements for each hazard.

The problem statements for each plan were reviewed and analyzed to determine common challenges, takeaways, and proposed actions highlighted across the local plans. The following section provides a summary of the key points and challenges discussed in the problem statements for each hazard. This analysis is helpful as it provides a high-level overview of what is important at the county level and can be referenced by the state to ensure future mitigation efforts reflect the key risks and challenges highlighted in the local plans.

Flooding

All local county plans addressed flood hazards. Most problem statements summarized that flash flooding and riverine flooding were the most common type of flood hazard to impact the counties and jurisdictions. Some plans noted levee and dam failure as costly sources of flooding, however, counties with more consistent levee and dam failure challenges detailed those issues in a separate analysis.

Many of the problem statements noted that the majority of recent presidential disasters in Missouri, and their respective counties, have included flood-related hazards. Several plans also referenced past events data (NCEI), HAZUS analysis, and repetitive loss data to summarize potential risk and exposure to flooding.

Some of the common challenges summarized in the problem statements included damage to low water crossings and other localized flooding challenges, flood risk along or in close proximity to water bodies, and flood awareness. Recommendations included the assessment of frequently flooded low water crossings and the installation of warning signs, gauges, and warning lights; improvements and restoration of river and stream banks; stormwater management projects; and improved emergency warning systems that include various ways to notify people of flood hazards and where they are located.

Levee Failure

As noted in the previous section, only 70 counties analyzed levee failure. Many of the counties that did analyze levee failure did not elaborate on key challenges or takeaways in their problem statements. This was either due to minimal risk or lack of past occurrences. Counties with larger levee systems had more specific summaries noting local challenges and future actions. However, like dam failure, there are common challenges and suggestions mentioned in many problem statements.

Regular maintenance and frequent inspections of levees, particularly privately owned levees, are the most common recommendation. Several plans mentioned low-head agricultural levees and the need for regular inspection, as they are not regulated. Counties noted that residents need to be informed on how to perform inspections and should be made aware of the risks of living near/downstream of a levee. In addition, many plans suggested the need for emergency evacuation plans for at risk communities.

Dam Failure

Dam failure was identified as being a high-risk hazard for some counties and moderate to low for others, often depending on the number of dams and proximity to development. However, across problem statements, each county recognized the potential for significant damage if a failure were to occur.

Several problem statements highlighted a need to expand public education about dam failure hazards and the risk of continued development within inundation areas. However, lack of mapped inundation areas and GIS capabilities was a common challenge noted in the plans' problem statements. Most plans suggested a need to expand mapping capabilities and the necessity of mapped inundation areas for emergency management and planning purposes. Additionally, local problem statements identified the need to develop and publicize emergency action and evacuation plans for developed areas in close proximity to dams.

The most common takeaway noted in almost all problem statements was the lack of regular inspections and maintenance of dams. Many plans noted that dams are not inspected properly or frequently enough. Suggestions include developing a consistent maintenance and inspection schedule, identify qualified staff to properly inspect dams, and train private dam owners on proper inspection methods.

Earthquake

A review of the plans' problem statements revealed that there are varying levels of risk from earthquakes among the counties. Many counties noted that their level of risk was dependent upon geographical location and vulnerability of buildings and infrastructure. Vulnerability was largely attributed to age of properties and infrastructure. Across almost all problem statements, the plans highlighted the importance of updating and enforcing new building codes that are earthquake resistant. Many suggested retrofitting old properties and ensuring new development follows updated codes. Additionally, several counties noted the challenges presented when earthquakes cause disruption to transportation, water, sewer, and electrical systems. Many suggested the need to evaluate facilities and infrastructure for seismic hazards as damage and disruption could worsen response and recovery efforts. It was also recommended that localities ensure adequate emergency generators at necessary facilities (water, medical, etc.).

The analysis also noted that earthquakes often occur with little warning and people may be unaware of how to respond and seek shelter. Several counties encouraged jurisdictions to educate citizens about how to respond to earthquakes, and support education campaigns and additional materials to further help the public better understand what to do if an earthquake occurs.

Land Subsidence and Sinkholes

The county plans noted that land subsidence and sinkholes are localized hazards with varying risks dependent on geology and land uses – many noted that areas near old mining sites tend to be vulnerable to sinkholes. As a result, several plans specified the need to develop accurate and updated maps of known sinkholes and sinkhole-prone areas and utilize them for public awareness about associated risks. Similarly, most plans highlighted the need to divert development from sinkhole-prone areas and remediated sinkholes. Counties suggested that undeveloped land near high-risk areas can be used as park space or other recreational uses.

Flood and groundwater contamination were common secondary issues mentioned in many of the problem statements. Counties where sinkholes and land subsidence are more common, noted the importance of diverting stormwater from known risk areas these challenges.

Drought

Across all counties, the problem statements highlighted the increased risk of drought to the agricultural sector. Counties with a larger focus on agriculture noted the need to assess water management practices and assess equipment to encourage water conservation. Several plans also encouraged farmers to have crop insurance policies that help with any losses experienced during periods of drought.

Many counties also noted the increased risk faced by rural areas, and the need to establish agreements with either regional or local communities and ensure a secondary water source. Several problem statements noted that this is particularly important for rural areas experiencing increased development and population growth. Additional takeaways include the need to develop and implement a water conservation ordinance or plan that limits non-essential water usage during periods of drought. Similarly, many problem statements encouraged voluntary water conservation by the public. Examples include public campaigns that notify residents of current drought conditions, when droughts are most likely to occur, and how to conserve water.

Extreme Temperatures (Heat)

In the problem statements, counties recognized that heat waves and extreme temperatures are regional in nature, spanning county and jurisdictional boundaries. While risk to heat-related hazards vary, all counties are likely to face some exposure to extreme heat. Across the problem statements, the counties highlight the increased risks facing vulnerable populations. Vulnerable populations include the very young, people over the age of 65, and people living in poverty. Several counties examined what percentage of their population is vulnerable (based on age and income) and discussed potential ways to support those most at risk. Some counties performed this analysis at both the county and jurisdictional level.

Potential solutions included creating a database of vulnerable elderly populations and establishing a check-in program that ensures their safety during a heat event. Several plans suggested the establishment of cooling centers and adequate access to public facilities as households and residents without access to air conditioning or shelter can seek protection from extreme temperatures. Counties also noted the need for backup generators as increased electricity usage can cause power blackouts. Almost all counties noted the need for increased education on heat exposure and health impacts. Many plans suggested a wide range of outreach methods as those more vulnerable tend to be difficult to reach.

Many counties noted that urban areas tend to be more at risk of extreme heat than rural areas that have less impervious surface cover and more tree coverage. However, counties with more agricultural land may be at risk due to the impact of heat on crops and livestock. Local plans suggested education and training on best practices and insurance protection.

Severe Thunderstorms/Lightning

Nearly all the counties analyzed thunderstorms that included an assessment of hail, high wind, and lightning in their analysis. Problem statements summarized the many assets (buildings, roofs, cars, etc.) at risk of physical damage from either wind, hail, or lightning. The summaries noted secondary consequences of interrupted power sources due to utility damage and the vulnerability of old buildings to hail and wind. Counties also noted potential crop damage as a risk for farmers and the agricultural sector. Several problem statements suggested access to public facilities for shelter during severe weather, and crop insurance for farmers. Many counties noted the importance of early warning systems and the use of multiple notification strategies (radio, social media, text, etc.).

Severe Winter Weather

Nearly all counties analyzed winter weather as it tends to be a region-wide hazard with similar levels of risk and similar impacts across counties. The plans noted common impacts from snow, extreme cold, and ice, like disruptions to transportation, damage to utility lines, and property damage from heavy snow and fallen trees. Across the problem statements, counties identified vulnerable populations as the elderly, people living in poverty and the homeless, and people living in rural areas that may be cut off from resources and services during winter weather events.

Common suggestions included the creation of snow removal plans, access to emergency shelters with backup generators, vegetation management plans to minimize icy branches prone to collapse, and crop insurance for farmers.

Tornadoes

Several of the problem statements for tornados noted the extent and cost of damage from past tornados, referencing this data more than any other hazard summary. Several counties stressed the potential for costly destruction and the wide range of impacts tornados can have on communities. Many counties noted that densely populated areas and schools tend to have higher risks due to the concentration of infrastructure and people. However, counties with rural communities noted that residents in less populated areas may lack adequate warning sirens to alert people of potential tornados. This was highlighted as a key challenge as most plans recognized that adequate warning time is the best way to minimize loss of life and injury. As such, several plans stressed the need to maintain or explore multiple methods for community warning systems.

Additionally, most problem statements focused on the importance of shelters and saferooms. Several suggested the development of FEMA approved saferooms, designation of public facilities as shelters, and development of shelters in and around schools. Many plans focused on potential actions for schools and children as adequate shelter and time may be limited. Many noted the importance of school drills.

Other commonalities included discussion of property protection and building retrofits such as roof tiedown straps, shatter-proof windows and, and updated building codes. Several plans noted that any building updates should prioritize infrastructure for vulnerable populations like nursing homes, schools, and public shelters.

Fires (Wild and Structural/Urban)

Some local plans assessed urban and structural fires in addition to wildfire, however, most counties focused on assessing the risks posed by wildfire. Across almost all problem statements, counties identified the wildland-urban interface (WUI) and unincorporated portions of the county to have the highest risk and exposure to wildfires. In these areas, counties recommended the use of fire-resistant construction materials and landscape design techniques to mitigate risks to future development. Several plans mentioned the Missouri Department of Conservation publication, *Wildfire Prevention*, as a source of information on construction materials and design techniques.

The local plans identified education and general fire awareness and compliance to be the leading challenge facing wildfire safety. Problem statements from the local plans emphasized an overall lack of education in fire safety, particularly knowledge of evacuation routes and areas of increased risk. Additionally, the plans called out residents' lack of awareness or non-compliance with burn bans. Several plans noted the use of social media and text messages to promote awareness of potential fire threats, however, many plans stressed the need for additional education opportunities as these may not be the best lines of communication to reach the more vulnerable members of the population.

3.4.4. Overview of Local Mitigation Actions

For this State Plan Update, a review was conducted of the mitigation actions for each of the local plans focusing on county-wide actions. **Table 3.99** presents a breakdown of the total number of mitigation strategies for each overarching mitigation category. The categories used in this assessment generally correspond with the six recommended FEMA mitigation categories and include prevention, property protection, public education and awareness, emergency services, natural resource protection, and structural projects.

Table 3.99. Summary of Mitigation Actions

Mitigation Category	Number of Actions
Prevention	637
Emergency Services	468
Public Education	439
Property Protection	276
Structural Projects	256
Natural Resource Protections	102
Total	**2,178**

As shown in **Table 3.99**, almost a third of the local mitigation actions are centered around prevention, while just over 4% of mitigation actions are related to natural resource protections. Similarly, structural projects, which tend to include more expensive mitigation actions, only make up a little over 11% of the reviewed strategies.

Within each mitigation category, there are several different mitigation action approaches. Subcategories were identified to better assess the types of actions included in the local mitigation strategies. The selected mitigation projects do not necessarily fit into each subcategory perfectly but help to understand the range of different actions. The subcategories and the number of local actions can be found in **Table 3.100.**

A large number of prevention mitigation actions were related to updating or developing plans and studies. Such actions included updating emergency operations plans, increasing participation in local mitigation planning, creation of stormwater management studies, improve plan integration for relevant plans, complete localized flood studies, and more. There are also several actions related to regulations, codes, and policy. While there is a wide variety of actions, floodplain regulations, stormwater management regulations, and building code updates seem to be the most common. Other common actions include updating GIS mapping capabilities and access to data, maintaining NFIP and CRS eligibility, creating inventory/list of important emergency contacts and vulnerable populations, and establishing mutual aid agreements. As shown in **Table 3.100**, there are 147 “other” actions that do not fit within this category. Like the other categories, many of the mitigation actions are listed as “other” due to the wide variety of mitigation approaches specific to the challenges and needs outlined in the local plans.

The mitigation actions within the property protection category fell within three main subcategories: Bridge/Culvert/Roadway Upgrades and Repairs, Retrofitting, and Acquisitions/Elevations. Over 70 actions are related to infrastructure upgrades and repairs. Most of these strategies are related to flood hazards. Other popular subcategories include retrofitting buildings for a range of hazards (66), and acquisitions and elevations to mitigate flood risk (40).

Almost 50% of the mitigation actions within the public education category are focused on public outreach campaigns and programs aimed at increasing public awareness of certain hazards, safety measures, or mitigation initiatives. Several plans also include actions focused on training and drills like weather spotter training, tornado drills at schools, emergency training for citizens, and more. The development and distribution of brochures and publications, particularly on hazard safety, is another common mitigation action.

Emergency services is the second most common mitigation action category and has a wide variety of mitigation approaches. The most common emergency service action is the implementation of warning systems, alerts, and sirens. Several plans also include the need for new generators and backup power sources, or an assessment of necessary locations. Other common strategies include the establishment of shelters, actions related to communication such as integration of communication systems, improved communication infrastructure, accessible contact information, increased capability, and resources for first responders and other relevant personnel.

Mitigation actions specific to natural resource protection were not as common in the local mitigation plans. Most of the plans focus on actions that help with flood mitigation including debris clean up, reducing runoff, and green infrastructure focused on water infiltration. There are also fewer structural projects compared to the other mitigation categories. Over 40% of the structural projects are focused on the development of saferooms and community shelters. The other action items are related to capital improvement and drainage projects. A few plans also included levee and dam upgrades in their mitigation strategies.

The table below summarizes the various subcategories and the number of actions within each. It should be noted that more than one subcategory may be applied to a single strategy. As a result, the totals in **Table 3.100** may exceed the total individual mitigation action count in **Table 3.99**.

Table 3.100. Hazard Mitigation Actions by Mitigation Category

Prevention	Number of Local Actions
Codes/Regulations/Policies	154
Plans/Studies	162
GIS/Mapping/Data	81
Ordinance/NFIP/CRS	87
List/Inventories	21
Mutual Aid Agreements	13
Zoning	2
Other	147
TOTAL	**667**
Property Protection	**Number of Local Actions**
Bridge/Culvert/Roadway Upgrades and Repairs	76
Retrofitting	66
Acquisitions/Elevations	40
Elevations	23
Utilities/Bury Underground	20
Inspections	10
Manufactured Homes	3
Other	50
TOTAL	**288**

Public Education	Number of Local Actions
Campaign/Program/Education/Inform/Publicize	211
Training/Exercises/Drills/Classes	71
Brochures/Publications	32
NOAA Radios	17
TV/Cable/Radio Outlets	4
Fans/Air Conditioning	6
Other	105
TOTAL	**446**
Emergency Services	**Number of Local Actions**
Warning Systems/Siren/Alert	152
Generators/Backup Power	83
Communications	45
Sheltering	42
Designate EOC	14
Equipment - General	34
Snow Fighting Capabilities/Equipment	12
Other	82
TOTAL	**464**
Natural Resource Protection	**Number of Local Actions**
Clean debris/sediment from channels/bridges	17
BMPs/Stream Buffer/Green Infrastructure	14
Tree Trimming practices	12
Open Space Acquisition	11
Drought practices	10
Clean debris from buildings and surrounding areas	10
Watershed Practices	1
Alternate uses of floodplains	2
Other	24
Total	**101**
Structural Projects	**Number of Local Actions**
Safe Room/Community Shelter	114
Drainage Project/CIP	64
Levee	16
Dam	15
EOC/Critical Facility	12
Water/Sewer	7
Storage Building	2
Other	35
TOTAL	**265**

3.5. State Owned and Operated Facilities: Vulnerability and Loss Estimates

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii): [The state risk assessment shall include an overview and analysis of the state's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in] the state risk assessment. State owned critical or operated facilities located in the identified hazard areas shall also be addressed.

[The State risk assessment shall include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

As Missouri remains vulnerable to natural hazards, state-owned or operated facilities are at risk to incur damage from hazard events. The state's resources, both monetary and fixed assets, depend heavily upon these facilities and their continuity. This section assesses vulnerability and potential losses to state-owned or operated facilities. According to the regulatory requirements of the Disaster Mitigation Act, the State must provide an overview vulnerability analysis and loss estimates for state-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas. To perform this analysis, identified hazard areas exist for the following hazards: dam failure, earthquake, flood, and levee failure. During the 2023 update, new data allowed for the analysis of vulnerability to sinkholes, wildfire, and hazardous materials fixed facility incidents. Therefore, for those hazards, a more comprehensive analysis was completed, including loss estimates. For the remaining hazards, clearly identified hazard areas are not established due to the random nature of the hazard (as with severe thunderstorms or tornadoes). For these hazards, where appropriate, the State has utilized the statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability. For some of the hazards addressed, a narrative is provided to discuss vulnerability of state- owned facilities. Where data is available, vulnerability and loss estimation are described in more detail by hazard in this section. Updates in this section for each hazard profiled include:

Table 3.101. Summary of Vulnerability Analysis/Loss Estimation Update Methods

Natural Hazards	2023 Update	Natural Hazards	2023 Update
Riverine Flooding (Major and Flash)	GIS locations of updated State Owned and Leased facilities compared with NFHL and HAZUS-generated floodplains to determine counts and values at risk in the 100-year floodplain.	Drought	Updated Narrative
Levee Failure	GIS location analysis using the updated National Flood Hazard Layer which includes the levee certification in conjunction with the National Levee Inventory Database provided by the US Corps of Engineers.	Extreme Temperatures	Updated Narrative
Dam Failure	Identified State Owned and Leased Facilities (using GIS data) within available State-regulated dam inundation areas from Missouri Department of Natural Resources	Severe Winter Weather	Utilized results of statewide vulnerability analysis to identify State Owned and Leased facilities within counties indicated to have increased vulnerability.

Natural Hazards	2023 Update	Natural Hazards	2023 Update
	(MoDNR) and available USACE dam inundation areas from USACE.		
Earthquakes	GIS location analysis to identify State Owned and Leased Facilities based on the resulting Modified Mercalli Intensity and the corresponding Peak-Ground Acceleration (PGA) data.	Severe Thunderstorms	Utilized results of statewide vulnerability analysis to identify State Owned and Leased facilities within counties indicated to have increased vulnerability.
Land Subsidence /Sinkholes	GIS location analysis of updated State Owned and Leased facilities compared to Sinkhole GIS layer supplied by MoDNR, Missouri Geological Survey (MGS), Geological Survey Program (GSP), Environmental Geology Section (EGS).	Tornadoes	Utilized results of statewide vulnerability analysis to identify State Owned and Leased facilities within counties indicated to have increased vulnerability.
		Wildfire	Identified State Owned and Leased Facilities in Wildland Urban High Interface and Wildland Urban Intermix areas based on GIS layers from the University of Wisconsin SILVIS lab.

Manmade and Other Hazards	2023
Civil Disorder	Updated Narrative
Cyber Disruption	Updated Narrative
Environmental Health Emergencies	Updated Narrative
Hazardous Materials Release: Fixed facility accidents Transportation accidents	Identified State Owned and Leased facilities within 0.5-mile radius of Tier II Facilities.
Mass Transportation Accidents	Updated Narrative
Nuclear Power Plants (Emergencies and Accidents)	Identified State Owned and Leased facilities within 10-mile radius of nuclear power plants.
Public Health Emergencies	Updated Narrative
Special Events	Updated Narrative
Terrorism, including CBRNE Attack	Updated Narrative
Utilities (Interruptions and System Failures)	Updated Narrative

State-owned Facilities

As part of the 2023 update, major improvements to available facility and bridge data resulted in a greatly improved data set to base the vulnerability assessments and loss estimations from. The State Office of Administration facility inventory databases for owned and leased facilities was geo-referenced with available information (latitude longitude or address). In addition, the State obtained inventories from other state departments that are not captured in the Office of Administration inventory, including MODOT, DHE, and MDC**. Table 3.102** summarizes state-owned facilities data obtained for this 2023 plan update.

Table 3.102. State Facilities Inventories

Source/Inventory	Number of Facilities Geolocated
Office of Administration/State Facilities—includes the following: • Department of Agriculture (DOA) • Department of Corrections (DOC) • Department of Economic Development (DED) • Department of Elementary and Secondary Education (DESE) • Department of Labor and Industrial Relations (DLIR) Department of Mental Health (DMH) • Department of Natural Resources (MoDNR) • Department of Revenue (DOR) • Department of Social Services (DOSS) • Department of Public Safety (DPS)	7,229 (Owned) 612 (Leased)
• Missouri Department of Transportation (MoDOT)-facilities • Bridges	295 10,400
Department of Higher Education (DHE) /Public Colleges and Universities	2,453
Missouri Department of Conservation (MDC)	1,511

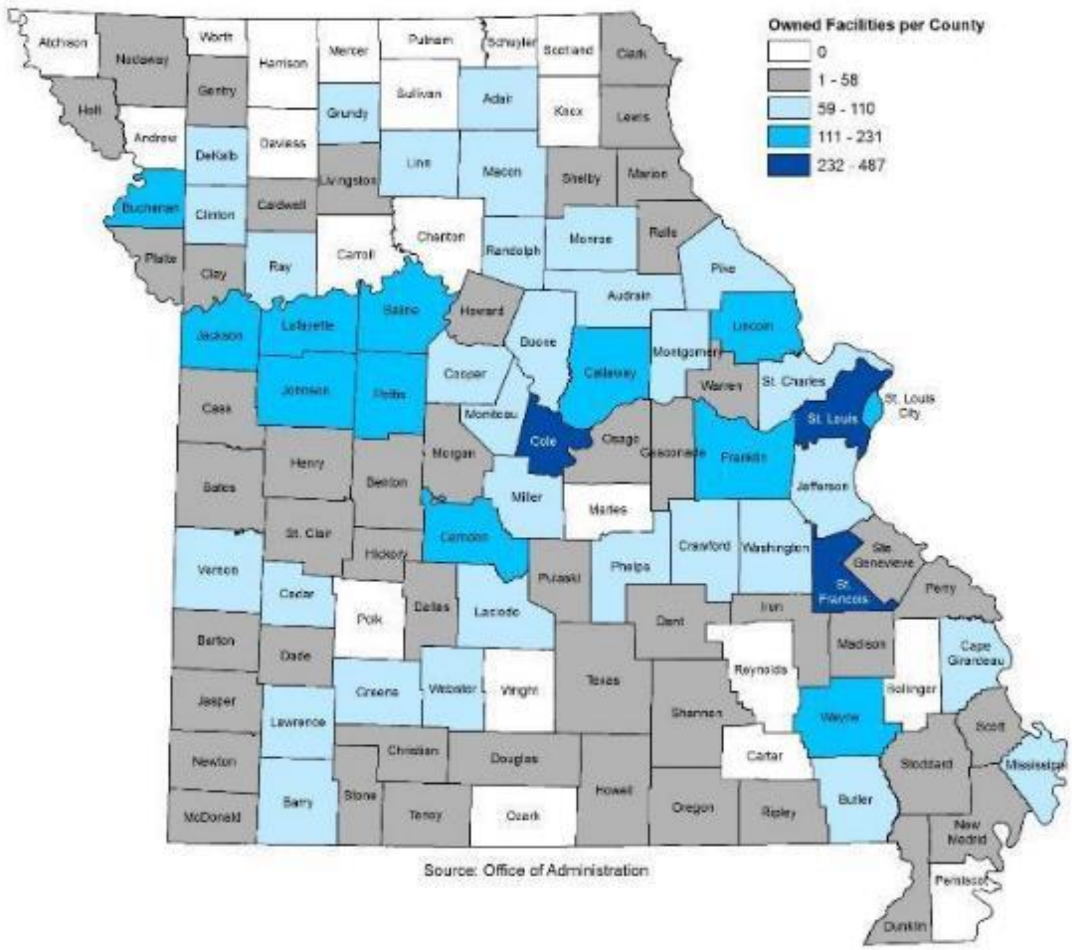
State-owned Bridges

In addition to inventories compiled for facilities, the inventory of State-owned bridges was obtained. This inventory consists of information on 10,400 state-owned bridges in Missouri. This inventory does include GIS information that allowed for GIS-based analysis.

State-leased Facilities

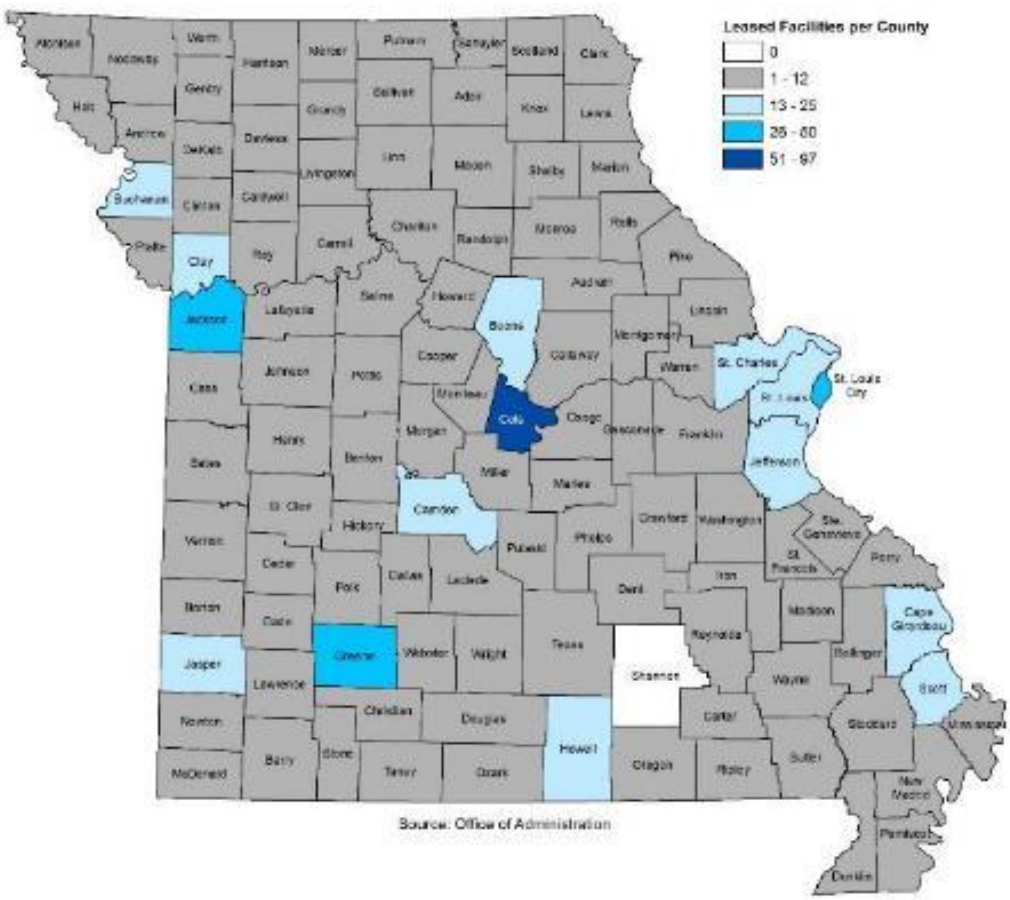
The State, through the Office of Administration, also currently leases space in 954 facilities. **Figure 3.176** provides the number of leased facilities in each county.

Figure 3.175. State-owned Facilities in Missouri



Source: Office of Administration

Figure 3.176. **State-leased Facilities in Missouri**



Critical Facility Determination

One of the first steps in providing for a meaningful analysis was the determination of critical facilities from the inventories available. FEMA's HAZUS-MH loss estimation software uses the following three categories of critical assets. 'Essential facilities' are those that if damaged would have devastating impacts on disaster response and/or recovery. 'High potential loss facilities' are those that would have a high loss or impact on the community. Transportation and lifeline facilities are third category of critical assets. For the facilities provided by the Office of Administration, Missouri Department of Transportation (MoDOT), and Missouri Department of Conservation (MDC) the State applied FEMA's guidelines for determining critical facilities to the asset use/facility types. For the MoDOT State Bridge Inventory, all were considered critical as were the education facilities provided by the Department of Higher Education (DHE). Not including the State bridge inventory, of the total 8,119 facilities in the remaining inventory, 1,950 were determined to be critical facilities.

Figure 3.177 provides the locations of the education facilities provided by the Department of Higher Education. **Figure 3.178** provides the locations of the MoDOT State Bridge Inventory.

Figure 3.177. Department of Higher Education Facilities

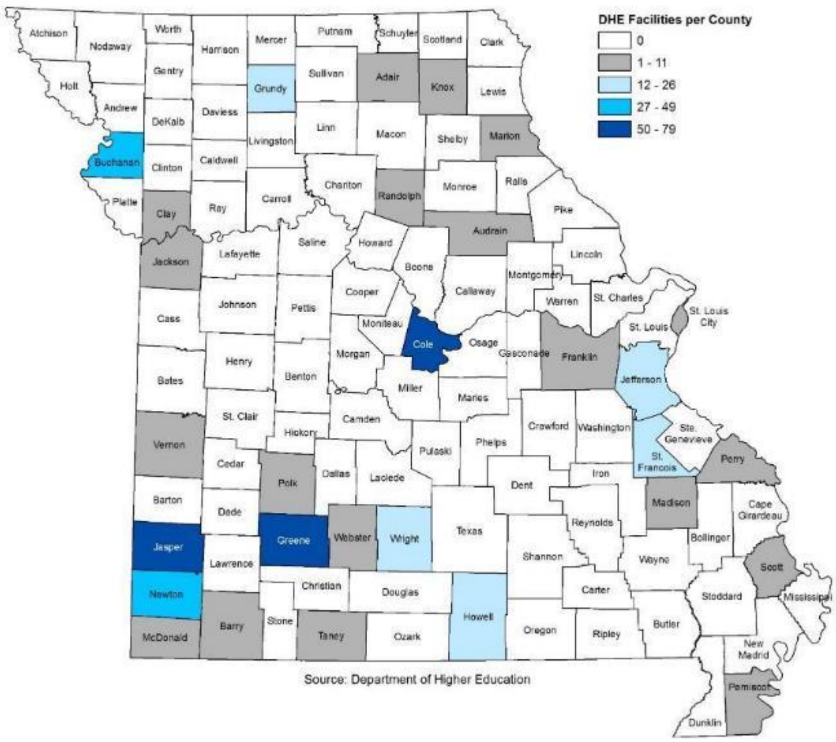


Figure 3.178. MoDOT Facilities and State-owned Bridges

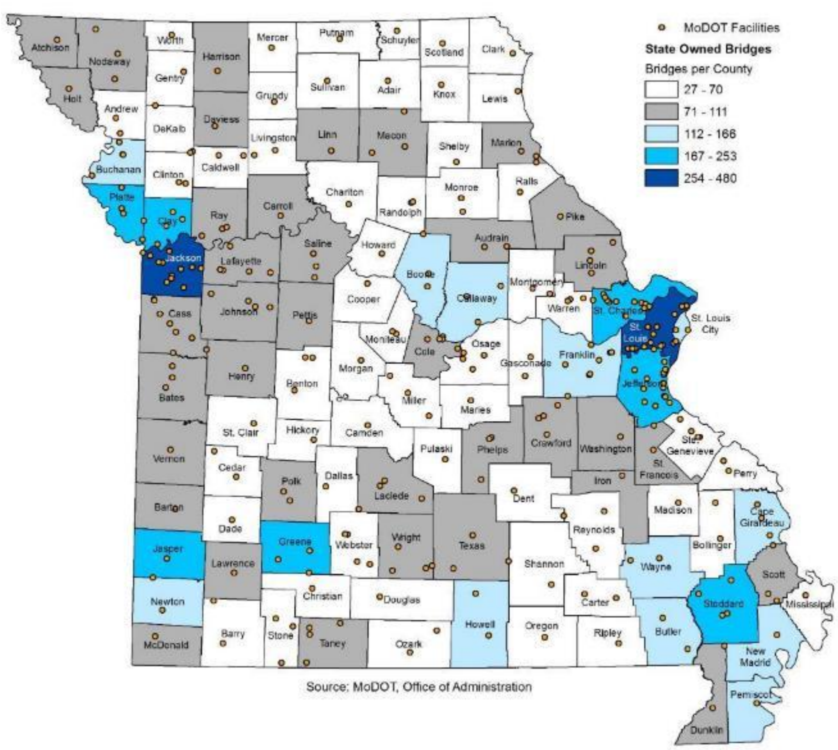


Table 3.103 lists the number of total facilities, the number of determined critical facilities, and the combined reported replacement cost summarized by state departments and divisions. The Departments of Corrections

and Higher Education contain some of the largest building exposure in terms of numbers and value of facilities. Another table that follows contains similar details for state leased facilities, including annual rent instead of replacement value.

Table 3.103. State-owned Facilities and Critical Facilities by Department

State Department/division	Replacement Cost	# of Facilities	# of Critical Facilities
DED - Tourism	$1,268,691	4	1
DED - Workforce Development	$12,637,406	13	0
DESE - Special Education	$235,092,575	266	70
DHE - Higher Education	$2,426,983,279	455	455
DHM - Developmental Disabilities	$352,665,694	383	89
DLIR - Employment Security	$69,829,669	23	2
DMH - Department Of Behavioral Health	$537,613,828	274	85
DOA - State Fairgrounds	$156,823,364	159	23
DOC - Adult Institutions	$2,141,533,779	1,154	566
DOC - Probation & Parole	$68,782,306	72	26
DOR - Lottery	$14,457,189	4	0
DPS - Adjutant General	$586,927,037	846	205
DPS - Highway Patrol	$141,193,815	255	129
DPS - Veteran's Commission	$270,558,971	211	53
DSS - Youth Services	$124,331,914	334	97
MDC - Conservation	$97,750,937	1,511	175
MoDNR – Missouri Geological Survey	$11,914,589	21	4
MoDNR - Parks & Historic Preservation	$451,479,478	2,953	709
MoDOT (Bridges)	$3,819,764,367	10,400	10,400
MoDOT (Facilities)	-	295	181
OA - Facilities Management, Design, & Construction	$975,478,488	257	31
Total	**$12,497,087,377**	**19,890**	**13,301**

Source: Missouri OA

Table 3.104. State Leased Facilities and Critical Facilities by Department

Space Use	Total Annual Rent	# of Facilities	# of Critical Facilities
ANTENNA	$1,562,786	105	105
ARMORY	$8,572	2	2
ARMORY, OFFICE	$21,462	1	1
COMMERCIAL DRIVERS' LICENSES (CDL)	$3,000	1	0
COMMERCIAL DRIVERS' LICENSES (CDL), OFFICE	$73,600	4	0
DAY TREATMENT	$982,296	7	7
GARAGE, OFFICE	$118,076	1	0
HANGAR	$4,800	1	1
INDUSTRIAL	$172,153	1	1
INSPECTION	$48,479	2	0
LABORATORY	$268,571	3	3
LAND	$194,212	46	0
OFFICE	$25,248,509	367	367
OFFICE, RESIDENTIAL	$484,584	3	3
OFFICE, SCHOOL	$110,464	1	1
OFFICE, WAREHOUSE	$786,647	7	1
PARKING	$1,132,217	22	0
RECRUITING OFFICES	$160,733	8	0
RESIDENTIAL	$184,905	5	0
SCHOOL	$280,661	6	6
STORAGE	$3,941	3	3
WAREHOUSE	$1,787,133	16	16
TOTAL	**$33,637,808**	**612**	**516**

Source: Office of Administration

Table 3.105 provides the total number of state-owned facilities and state-leased facilities for each county in Missouri compiled from all inventories obtained. The number of determined critical facilities is also provided for both state-owned and state-leased facilities. For owned facilities, the replacement value is summarized within each county and for the leased facilities, the total annual rent is summarized.

Table 3.105. State-owned and Leased Facilities in Missouri Counties

County	Total # of State-Owned Facilities[1]	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities[2]	State-leased # of Critical Facilities	Total Annual Rent
Adair	82	16	$16,020,933	8	7	$219,904
Andrew	0	0	$0	2	2	$12,401
Atchison	0	0	$0	6	4	$60,107
Audrain	72	28	$130,422,271	5	4	$62,858
Barry	99	24	$27,426,320	7	5	$174,886
Barton	44	11	$5,276,443	4	3	$64,654
Bates	28	10	$3,466,881	7	5	$116,135
Benton	37	13	$8,630,614	5	5	$52,807
Bollinger	0	0	$0	4	4	$32,826
Boone	81	23	$17,625,833	21	17	$1,647,280
Buchanan	247	83	$253,449,024	15	2	$283,996
Butler	90	30	$45,657,256	11	10	$455,552
Caldwell	1	0	$22,170	5	5	$35,433
Callaway	219	75	$589,730,429	6	3	$158,607
Camden	231	38	$23,944,431	13	9	$284,668
Cape Girardeau	110	33	$54,559,504	25	22	$1,499,536
Carroll	0	0	$0	3	3	$41,730
Carter	0	0	$0	1	1	$0
Cass	23	5	$6,656,370	7	7	$338,411
Cedar	62	11	$5,219,465	6	6	$60,303
Chariton	0	10	$2,382,005	3	3	$27,179
Christian	24	0	$0	8	7	$144,726
Clark	36	9	$3,978,747	4	3	$59,566
Clay	38	15	$17,284,344	14	12	$683,881
Clinton	61	13	$32,935,882	5	4	$46,635
Cole	561	129	$986,504,077	97	50	$8,930,147
Cooper	104	44	$88,831,919	5	4	$55,100
Crawford	77	19	$8,907,444	7	6	$77,670
Dade	7	5	$3,969,521	4	4	$7,295
Dallas	34	5	$7,276,446	4	4	$47,031
Daviess	0	0	$0	3	3	$33,323

County	Total # of State-Owned Facilities[1]	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities[2]	State-leased # of Critical Facilities	Total Annual Rent
DeKalb	102	58	$217,656,758	12	10	$169,588
Dent	44	7	$8,982,027	4	4	$124,344
Douglas	1	0	$192,684	3	3	$50,415
Dunklin	8	2	$4,331,627	9	9	$299,331
Franklin	147	42	$85,414,212	7	6	$347,770
Gasconade	15	5	$2,488,018	3	2	$20,803
Gentry	15	5	$8,188,639	1	1	$0
Greene	176	24	$100,674,983	38	17	$2,350,623
Grundy	85	13	$8,703,292	6	5	$111,564
Harrison	0	0	$0	7	5	$54,636
Henry	45	13	$13,437,154	7	7	$121,540
Hickory	58	13	$7,765,905	3	3	$41,591
Holt	39	12	$4,080,182	5	3	$32,270
Howard	11	1	$2,096,953	3	3	$45,501
Howell	37	9	$7,421,349	13	13	$421,191
Iron	56	14	$4,644,761	5	3	$76,407
Jackson	228	50	$237,568,751	50	29	$3,151,484
Jasper	117	15	$30,675,768	15	14	$774,015
Jefferson	117	32	$34,995,498	15	12	$809,498
Johnson	141	34	$47,402,996	9	6	$282,675
Knox	1	0	$0	2	2	$4,450
Laclede	71	22	$23,515,774	12	10	$227,047
Lafayette	133	38	$83,436,354	6	5	$115,368
Lawrence	65	15	$55,572,427	6	5	$131,402
Lewis	31	9	$5,111,723	4	3	$46,232
Lincoln	152	29	$27,855,622	7	5	$161,263
Linn	84	26	$5,352,718	4	4	$59,285
Livingston	34	17	$100,180,727	11	9	$131,570
Macon	96	20	$21,648,834	9	8	$358,444
Madison	10	3	$3,474,361	5	4	$74,180
Maries	0	0	$0	2	2	$14,740
Marion	53	13	$20,690,100	6	4	$127,028

County	Total # of State-Owned Facilities[1]	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities[2]	State-leased # of Critical Facilities	Total Annual Rent
McDonald	21	7	$3,690,392	5	5	$79,589
Mercer	0	0	$0	3	3	$19,265
Miller	72	41	$16,016,437	7	6	$146,711
Mississippi	66	29	$96,600,383	5	4	$170,530
Moniteau	63	33	$73,013,880	2	2	$6,761
Monroe	65	19	$9,886,967	3	2	$52,247
Montgomery	76	21	$17,189,293	4	4	$42,309
Morgan	5	3	$3,288,943	4	4	$54,231
New Madrid	45	15	$8,581,408	6	6	$122,253
Newton	62	0	$9,153,594	7	7	$243,196
Nodaway	42	20	$36,807,780	8	8	$82,798
Oregon	16	2	$240,033	6	4	$73,836
Osage	3	2	$151,926	2	2	$21,714
Ozark	0	0	$0	3	2	$65,568
Pemiscot	1	0	$0	7	7	$267,566
Perry	14	4	$3,765,787	5	4	$37,608
Pettis	195	34	$176,395,211	9	8	$310,849
Phelps	86	26	$58,342,451	9	8	$313,280
Pike	62	30	$133,656,408	4	4	$59,938
Platte	37	9	$3,662,580	6	5	$121,595
Polk	2	0	$0	7	7	$73,408
Pulaski	25	4	$2,081,201	9	7	$159,423
Putnam	0	0	$0	3	3	$18,824
Ralls	1	0	$17,382	3	3	$11,262
Randolph	114	42	$126,887,236	8	8	$164,825
Ray	71	8	$18,238,886	4	4	$62,566
Reynolds	0	0	$0	3	2	$53,121
Ripley	14	5	$5,199,536	2	1	$16,913
Saline	186	34	$156,521,129	6	6	$855,328
Schuyler	0	0	$0	2	2	$7,222
Scotland	0	0	$0	4	4	$88,577
Scott	46	10	$19,982,660	13	13	$406,691

County	Total # of State-Owned Facilities[1]	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities[2]	State-leased # of Critical Facilities	Total Annual Rent
Shannon	28	4	$0	0	0	$0
Shelby	7	7	$1,088,935	3	3	$31,706
St. Charles	69	24	$54,410,961	20	18	$1,155,426
St. Clair	3	0	$8,418	3	2	$11,727
St. Francois	404	130	$439,955,975	9	9	$420,655
St. Louis	457	103	$384,787,865	25	16	$1,033,685
St. Louis City	168	42	$434,254,891	44	11	$3,022,849
Ste. Genevieve	50	15	$5,723,773	5	4	$26,990
Stoddard	28	10	$10,833,446	7	6	$213,023
Stone	6	3	$907,052	6	5	$98,163
Sullivan	0	0	$0	4	3	$40,951
Taney	30	11	$4,989,562	11	9	$282,054
Texas	48	25	$106,178,657	5	5	$123,922
Vernon	106	23	$27,261,649	12	11	$787,130
Warren	10	3	$3,921,729	6	5	$119,596
Washington	87	29	$98,726,782	5	5	$134,030
Wayne	133	31	$34,142,496	2	2	$3,232
Webster	94	42	$52,286,573	6	6	$77,530
Worth	0	0	$0	2	2	$11,307
Wright	26	0	$0	6	6	$159,226
Totals	**7,684**	**2,090**	**$6,152,588,794**	**954**	**723**	**$38,414,107**

[1] MoDOT Bridges and facilities and MDC facilities are not included.

[2] Leased facility information by County available from 2017.

State Facilities in the 100-year Floodplain

To determine which state facilities are in the 100-year floodplain, the available GIS data was compared against the FEMA NFHL and Hazus generated floodplains (in areas lacking FEMA maps). **Table 3.106** provides the summary results of the analysis. **Table 3.107** shows the counts of the facilities by county.

Table 3.106. All State Facilities – Flood Hazard Analysis Summary

Facility Type	Total Facilities	Critical Facilities	Value of Structures/ Leased Amount
State-leased	41	36	$1,650,730
State-owned	478	90	$689,643,398
Dept Higher Education	8	8	$31,116,000
MDC Facilities	296	11	$11,707,249
MoDOT Facilities	15	10	-
Total	**838**	**155**	**$734,117,376**

At a conservative loss estimate of 25 percent, damages to state-owned facilities as a result of the 100-year flood could be $124M.

Table 3.107 provides the counties with state-owned facilities in the 100-year floodplain. For each county, the total number of state-owned facilities is provided along with the number of critical state-owned facilities and the total replacement cost for all state-owned facilities in the 100-year floodplain.

Table 3.107. State-owned Facilities in the 100-year Floodplain by County

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Adair	2	0	$44,106
Barry	15	3	$1,565,827
Barton	13	2	$4,272,551
Boone	8	0	$506,102
Buchanan	31	11	$30,880,719
Butler	2	0	$5,320,304
Callaway	48	15	$367,027,614
Camden	54	5	$6,572,208
Cape Girardeau	3	0	$962,495
Cedar	12	2	$970,213
Clark	1	0	$0
Cole	21	4	$194,458,518
Crawford	24	5	$1,056,704
Dallas	13	0	$3,564,897
Franklin	26	2	$3,466,838
Greene	1	1	$18,550

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Grundy	1	0	$420,452
Henry	11	2	$5,457,470
Holt	4	2	$152,436
Howard	6	0	$2,174,388
Jackson	17	4	$39,203,027
Jasper	10	6	$3,358,149
Jefferson	12	1	$663,035
Johnson	1	0	$18,956
Laclede	4	0	$656,194
Lewis	9	1	$432,175
Lincoln	2	1	$115,364
Linn	3	1	$260,300
Macon	2	0	$57,416
McDonald	5	3	$418,856
Miller	1	0	$19,856
Mississippi	16	2	$2,303,424
Monroe	2	0	$177,414
Montgomery	1	1	$6,307
New Madrid	6	3	$1,165,173
Oregon	11	2	$187,326
Pettis	1	0	$13,990
Saline	6	1	$211,977
Scott	10	3	$503,249
St. Charles	6	0	$537,027
St. Francois	20	4	$1,094,968
St. Louis	10	1	$6,007,812
Ste. Genevieve	3	0	$579,105
Taney	4	1	$218,485
Washington	8	1	$1,238,043
Wayne	12	0	$1,303,375
Total	**478**	**90**	**$689,643,398**

Table 3.108. State-leased Facilities in the 100-year Floodplain by County

County	# of State-leased Facilities	# of Critical State-leased Facilities
Barry	4	4
Callaway	1	0
Cole	1	0
Crawford	1	1
Greene	1	0
Henry	1	1
Holt	1	1
Howell	9	9
Jasper	1	1
Newton	1	1
Ozark	2	2
Pemiscot	6	6
St. Charles	1	0
St. Louis	7	6
Stone	3	3
Wayne	1	1
Total	41	36

Figure 3.179. State Facilities in the 100-year Floodplain

Facilities from DHE, MoDOT, and MDC were also analyzed for flood risk. The results are shown in the following tables. While DHE facility count is low, there is a high value exposure in Cole County. MDC has 296 facilities in floodplains across the state worth approximately $7.9M, but only 11 are designated as critical.

Table 3.109. DHE Facilities in the 100-year Floodplain by County

County	# of Facilities	# of Critical Facilities	Value of Structures
Cole	6	6	$23,285,735
Knox	1	1	$1,663,873
Pemiscot	1	1	$643,838
Total	**8**	**8**	**$25,593,446**

Table 3.110. MoDOT Facilities in the 100-year Floodplain by County

County	# of Facilities	# of Critical Facilities	Value of Structures
Callaway	1	0	-
Carroll	1	1	-
Henry	1	1	-
Holt	1	1	-
Jackson	1	1	-
Jefferson	1	0	-
Lawrence	1	1	-
Pemiscot	1	1	-
Platte	1	0	-
Ray	1	0	-
Reynolds	1	1	-
St. Louis	3	2	-
Wayne	1	1	-
Total	15	10	-

Table 3.111. MDC Facilities in the 100-year Floodplain by County

County	# of Facilities	# of Critical Facilities	Value of Structures
Andrew	2	0	$21,580
Atchison	1	0	$3,283
Bates	3	0	$32,159
Boone	13	1	$2,315,363
Buchanan	1	0	$9,118
Butler	5	0	$214,008
Callaway	1	0	$757,796
Camden	4	0	$66,564
Cape Girardeau	4	0	$159,267

County	# of Facilities	# of Critical Facilities	Value of Structures
Carroll	1	0	$9,118
Cedar	1	0	$426
Chariton	5	2	$17,629
Clark	5	0	$80,643
Clay	3	0	$21,884
Clinton	1	0	$14,097
Cole	8	0	$145,725
Cooper	12	0	$67,172
Crawford	3	0	$25,835
Dallas	7	0	$72,947
Dent	6	0	$373,412
Douglas	2	0	$11,550
Franklin	6	0	$94,231
Gasconade	2	0	$55,318
Henry	9	2	$107,376
Holt	23	1	$2,064,546
Howard	2	0	$66,868
Jackson	6	0	$129,724
Jefferson	1	0	$8,510
Johnson	4	0	$68,546
Knox	15	0	$50,129
Laclede	8	1	$1,061,701
Lafayette	10	0	$160,743
Lincoln	3	0	$32,097
Livingston	39	2	$576,300
Maries	3	0	$34,820
McDonald	1	0	$14,589
Miller	3	0	$57,506
Mississippi	2	0	$0
Osage	3	0	$42,552
Ozark	4	0	$38,540
Perry	6	0	$82,187
Phelps	1	0	$0
Pike	5	0	$32,875
Platte	15	2	$119,100
Pulaski	2	0	$14,371
Randolph	10	0	$129,883
Scott	4	0	$37,081
St. Charles	3	0	$4,717

County	# of Facilities	# of Critical Facilities	Value of Structures
St. Francois	1	0	$30,698
St. Louis	4	0	$32,218
Stone	3	0	$0
Taney	3	0	$15,416
Texas	3	0	$34,650
Vernon	2	0	$5,106
Worth	1	0	$4,620
Wright	1	0	$2,821
Total	**296**	**11**	**$9,629,414**

3.5.2. Levee Failure

A GIS location analysis was conducted to identify state facilities within areas of reduced flood risk due to levees. Two GIS data sets were used for levee protected areas. The National Flood Hazard Layer includes levee protected areas that are certified for 1% annual chance flood protection. A National Levee Inventory Database provided by the US Corps of Engineers shows other levee protected areas that may not be certified and includes a much larger area. The value field in the tables below present the value of assets exposed as a general indication of potential loss. Loss would vary depending on the extent and depth of flooding at a particular location. The total value of structures is provided.

Table 3.112. State Facilities in Levee Protected Areas – FEMA National Flood Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
Owned			
Scott	5	1	$6,467,072
Ste. Genevieve	10	1	$1,559,473
Subtotal	15	**2**	$8,026,543
Leased			
Clay	1	1	---
Scott	13	13	---
Subtotal	**14**	**14**	---

Table 3.113. State Facilities in Levee Protected Areas – Corp National Levee Inventory Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
Owned			
Buchanan	38	16	$26,527,594
Butler	1	0	$4,371,861
Callaway	17	2	$12,361,425
Dunklin	7	2	$4,308,493
Holt	27	7	$2,006,476
Howard	6	0	$1,788,472
Jackson	17	4	$32,245,165
Lewis	30	9	$5,016,513
Mississippi	65	29	$96,428,685
New Madrid	45	15	$8,581,408
Ray	2	1	$901,683
Scott	11	3	$5,214,070
St. Charles	5	0	$340,974
Ste. Genevieve	11	1	$1,583,771
Stoddard	14	4	$6,159,811
Subtotal	**296**	**93**	**$207,836,402**
Leased			
Callaway	1	0	---
Clay	1	1	---

County	# of Facilities	# of Critical Facilities	Value of Structures
Dunklin	9	9	$299,331
Mississippi	5	4	$170,530
New Madrid	6	6	$122,253
Pemiscot	7	7	$267,566
St. Charles	1	0	$0
Ste. Genevieve	1	1	$1,094
Subtotal	**31**	**28**	**$935,405**

Table 3.114. DHE and MODOT Facilities in Levee Protected Areas – FEMA National Flood Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
DHE Facilities			
Jackson	1	1	$0
Scott	1	1	$510,364
DHE Total	2	2	$510,364
MODOT Facilities			
Scott	2	2	-
St. Charles	1	0	-
St. Louis City	1	1	-
Total	4	3	-

Table 3.115. DHE and MODOT Facilities in Levee Protected Areas – Corp National Levee Inventory Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
DHE Facilities			
Jackson	1	1	$0
Pemiscot	1	1	$643,838
St. Louis City	1	1	$982,559
Subtotal	**3**	**3**	**$1,626,398**
MODOT Facilities			
Butler	1	1	-
Callaway	1	0	-
Carroll	1	1	-
Dunklin	2	2	-
Jackson	1	1	-
Mississippi	1	1	-
New Madrid	1	1	-
Pemiscot	1	1	-
Scott	2	2	-

County	# of Facilities	# of Critical Facilities	Value of Structures
St. Charles	1	0	-
St. Louis City	1	1	-
Subtotal	13	11	-

Table 3.116. MDC Facilities in Levee Protected Areas – Corp National Levee Inventory Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
Bollinger	38	3	$347,300
Boone	12	1	$2,275,242
Butler	3	0	$75,865
Callaway	1	0	$757,796
Dunklin	1	0	$21,884
Holt	5	0	$777,248
Howard	1	0	$54,710
Lincoln	1	0	$13,374
Mississippi	14	1	$14,589
New Madrid	4	2	$31,353
Pemiscot	8	2	$218,536
Platte	3	0	$11,185
Saline	7	0	$1,788,814
St. Charles	2	0	$4,717
St. Louis	12	2	$2,510,847
Total	**112**	**11**	**$8,903,460**

Figure 3.180. State Owned and Leased Facilities in Areas Protected by Levee

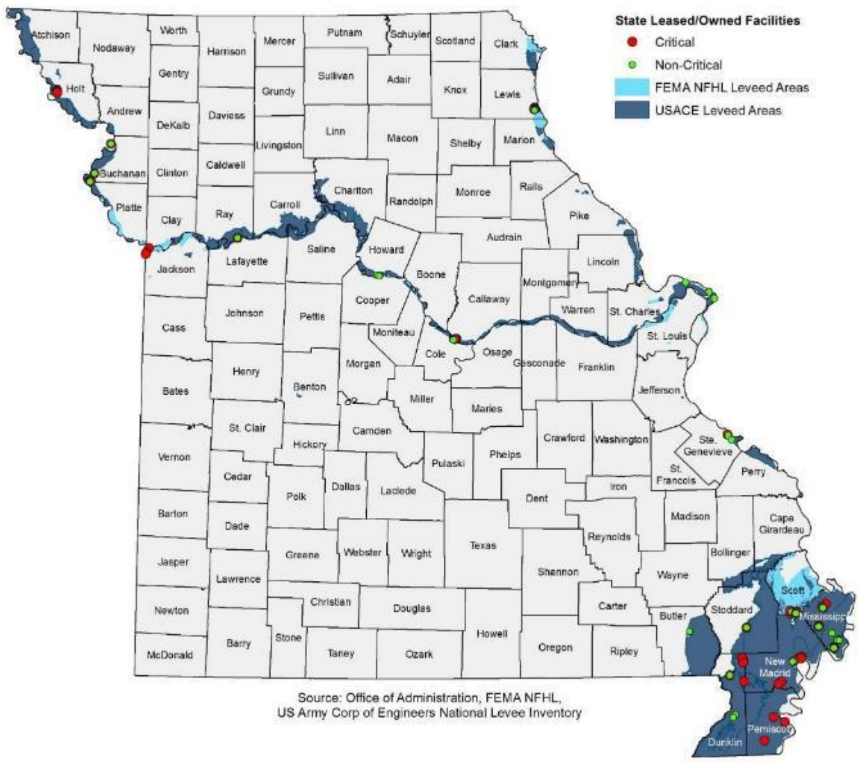
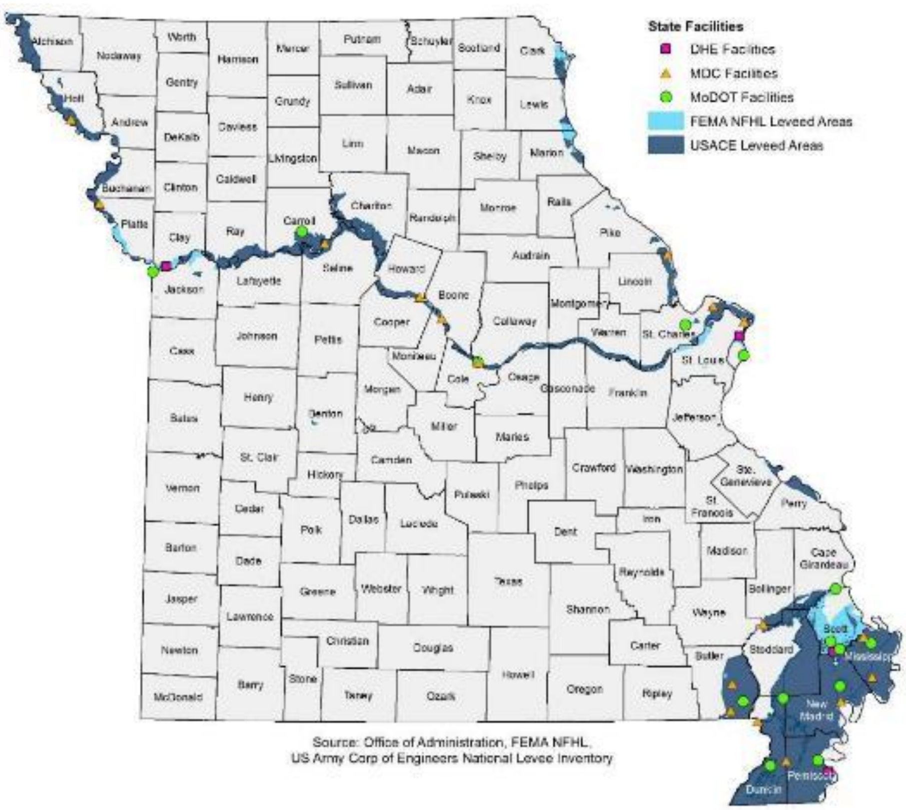


Figure 3.181. DHE, MODOT and MDC Facilities in Areas Protected by Levee



3.5.3. Dam Failure

State facilities potentially vulnerable to dam failure were identified by their location within available State-regulated dam inundation areas from MoDNR and USACE dam inundation areas. This refined analysis resulted in 505 total state-owned facilities in potential inundation zones, and 42 leased facilities. No DHE education facilities or MoDOT facilities intersected the inundation zones. A total of 255 MDC facilities (13 designated as critical) worth $14M intersected the inundation zones. **Table 3.117, Table 3.119** provide additional details regarding state facilities and total replacement value summarized by county and **Figure 3.182** shows the locations.

Table 3.117. State-owned Facilities in Inundation Zones of USACE dams by County

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Adair	2	0	$36,278
Benton	4	3	$0
Boone	8	0	$65,673
Buchanan	41	16	$29,211,280
Butler	15	4	$12,295,254
Callaway	65	18	$288,847,100
Camden	71	6	$6,943,929
Clark	6	1	$595,831
Clay	1	0	$332,066
Cole	142	35	$513,972,840
Cooper	5	3	$348,479
Franklin	7	0	$2,316,586
Gasconade	8	3	$1,930,619
Holt	39	12	$4,080,182
Howard	7	0	$1,820,229
Jackson	21	5	$32,588,345
Lewis	11	3	$653,673
Macon	1	1	$186
Miller	1	0	$16,332
Platte	19	5	$2,331,120
Ray	2	1	$901,683
Saline	12	1	$342,951
St. Charles	6	0	$441,714
St. Louis	5	3	$72,278
Taney	6	3	$2,896,891
Total	**505**	**123**	**$903,041,515**

Table 3.118. Leased Facilities in Inundation Zones of USACE dams by County

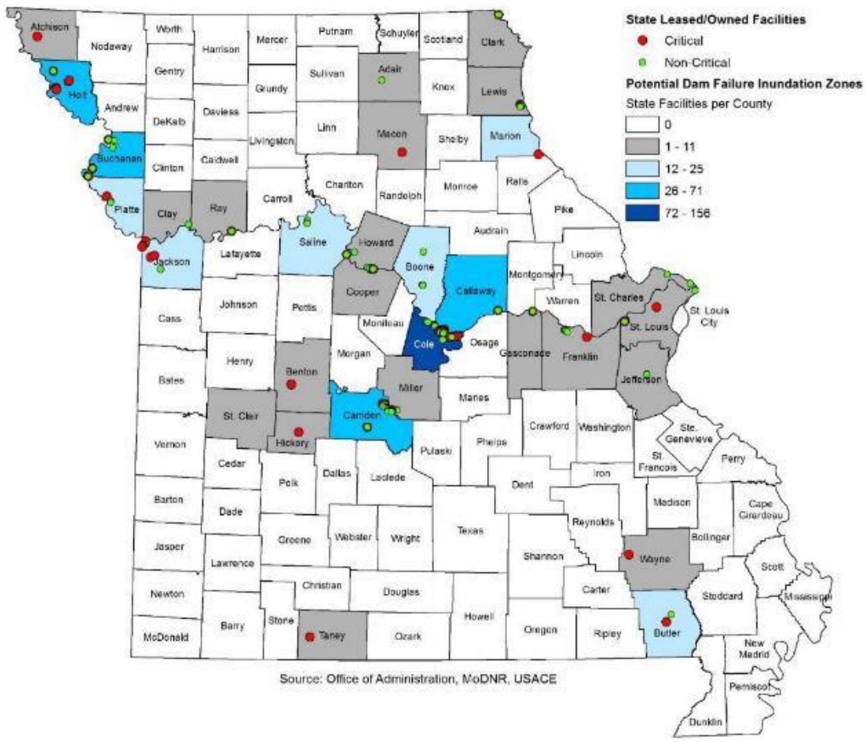
County	# of State-Leased Facilities	# of Critical State-Leased Facilities
Atchison	2	2
Benton	2	2
Buchanan	1	0
Callaway	1	0
Clay	1	1
Cole	14	1
Cooper	4	3
Franklin	2	2
Hickory	3	3
Holt	3	3
Jackson	4	3
St. Charles	1	0
St. Louis	1	1
Taney	2	0
Wayne	1	1
Total	**42**	**22**

Table 3.119. State-owned Facilities Within Inundation Areas of State Regulated Dams

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Adair	2	0	$36,278
Boone	6	0	$200,199
Jefferson	4	0	$61,520
Marion	13	5	$5,108,861
Total	**25**	**5**	**$5,406,857**

A precise loss estimate based on depth-damage information for state-owned facilities in potential dam inundation areas was not possible due to data limitations. However, the exposure of state facilities as an estimate of potential losses from dam failure is high.

Figure 3.182. State Facilities in Potential Dam Failure Inundation Zones



3.5.4. Earthquakes

Potential for Damage to State-owned Facilities Resulting from Earthquake

This analysis was limited to the facilities with available GIS data from the Office of Administration, and MoDOT bridges. Based on the resulting Modified Mercalli Intensity and the corresponding Peak-Ground Acceleration (PGA), perceived shaking and potential damage classifications were determined. **Table 3.120** provides the perceived shaking and potential damage classifications for the Modified Mercalli Intensity and approximate corresponding PGA.

Table 3.120. Ground Shaking and Potential Damage Classifications

Modified Mercalli Intensity	Acceleration (%g) (PGA)	2% Map Contour Range (%g) (PGA)	Perceived Shaking	Potential Damage
I	<0.17	0-2	Not felt	None
II	0.17 – 1.4	0-2	Weak	None
III	0.17 – 1.4	0-2	Weak	None
IV	1.4 – 3.9	2-4	Light	None
V	3.9 – 9.2	4-10	Moderate	Very Light
VI	9.2 – 18	10-18	Strong	Light
VII	18 – 34	18-30	Very Strong	Moderate
VIII	34 – 65	30-60	Severe	Moderate to Heavy
IX	65 – 124	60-120	Violent	Heavy

Modified Mercalli Intensity	Acceleration (%g) (PGA)	2% Map Contour Range (%g) (PGA)	Perceived Shaking	Potential Damage
X	>124	120-160	Extreme	Very Heavy
XI	>124	160- 200	Extreme	Very Heavy
XII	>124	200	Extreme	Very Heavy

Facilities

To determine the State-owned facilities at risk to earthquake and loss estimates, the USGS ground shaking grid contour map with a 2% probability of exceedance in the next 50 years was compared against the locations of State-owned and leased facilities provided in GIS format from the Office of Administration and Department of Higher Education. GIS analysis enabled the potential peak ground acceleration (PGA) (as expressed as % of gravity) with a 2% probability of exceedance in the next 50 years event to be assigned to each facility. Based on the PGA for each state-facility, the perceived shaking and potential damage classifications were applied. To generate potential loss estimates, a percent loss was applied to the potential damage classifications in the following manner: Very Light-10 percent, Light-20 percent, Moderate-30 percent, Moderate to Heavy-40 percent, Heavy-50 percent, and Very Heavy-60 percent. By applying the percent loss to the replacement values of the State-owned facilities, this analysis resulted in approximately estimated $802,063,414,900M in damages as a result of the earthquake scenario with a 2% probability of exceedance in the next 50 years. It should be noted that only the structure replacement value was considered in this loss estimate as contents value was not available. If contents value had been included, the loss estimate would be much higher. **Table 3.121** provides the summary results of this analysis. Site-specific information resulting from this analysis is available to authorized users at the following link: state-owned facilities earthquake analysis (password protected).

Table 3.121. State-owned Facilities and Earthquake Potential Damage

Potential Damage Classification	# of Facilities	# of Critical Facilities	Total Replacement Value	Estimated Damage
Very Heavy	156	54	$125,164,451	$75,098,670
Heavy	121	32	$85,484,550	$42,742,274
Moderate to Heavy	685	201	$352,524,263	$141,009,705
Moderate	1,213	338	$1,264,635,721	$379,390,717
Light	623	204	$309,215,544	$61,843,108
Very Light	4,295	1,216	$3,963,412,580	$396,341,258
None	136	45	$52,151,685	$0
Total	**7,229**	**2,090**	**$6,152,588,794**	**$1,096,425,734**

Table 3.122. State-leased Facilities and Earthquake Potential Damage

Potential Damage Classification	# of Facilities	# of Critical Facilities
Very Heavy	40	39
Heavy	40	36
Moderate to Heavy	42	35
Moderate	118	69
Light	112	97
Very Light	561	413
None	41	34
Total	**954**	**723**

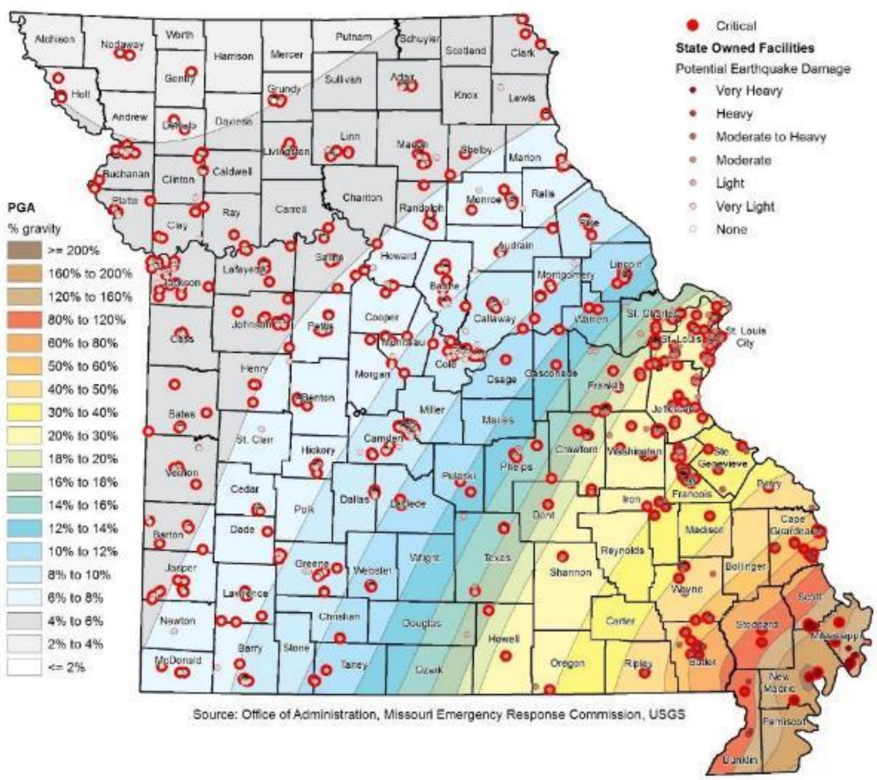
Table 3.123 provides a summary of the State-owned facilities in 25 counties that could receive moderate, moderate to heavy, heavy, or very heavy damages. For each county, the total number of state-owned facilities in these categories is provided along with the number of critical state-owned facilities in each category. **Figure 3.183** details the location of these facilities.

Table 3.123. State-owned Facilities With Resulting Earthquake Potential Damages of Moderate and Higher Reported by County

County	Total Moderate and Higher	Very Heavy		Heavy		Moderate to Heavy		Moderate	
		Total	Critical	Total	Critical	Total	Critical	Total	Critical
Butler	90	-	-	41	9	49	21	-	-
Cape Girardeau	110	-	-	44	11	66	22	-	-
Crawford	65	-	-	-	-	-	-	65	15
Dent	44	-	-	-	-	-	-	44	7
Dunklin	8	-	-	8	2	-	-	-	-
Franklin	106	-	-	-	-	-	-	106	36
Howell	8	-	-	-	-	-	-	8	3
Iron	56	-	-	-	-	50	12	6	2
Jefferson	98	-	-	-	-	-	-	98	32
Madison	9	-	-	-	-	9	3	-	-
Mississippi	66	66	29	-	-	-	-	-	-
New Madrid	45	45	15	-	-	-	-	-	-
Oregon	16	-	-	-	-	-	-	16	2
Perry	13	-	-	-	-	13	4	-	-
Ripley	14	-	-	-	-	14	5	-	-
Scott	45	45	10	-	-	-	-	-	-
Shannon	28	-	-	-	-	-	-	28	4
St. Charles	52	-	-	-	-	-	-	52	21
St. Francois	380	-	-	-	-	301	88	79	42
St. Louis	457	-	-	-	-	-	-	457	103

County	Total Moderate and Higher	Very Heavy		Heavy		Moderate to Heavy		Moderate	
St. Louis City	167	-	-	-	-	-	-	167	42
Ste. Genevieve	50	-	-	-	-	50	15	-	-
Stoddard	28	-	-	28	10	-	-	-	-
Washington	87	-	-	-	-	-	-	87	29
Wayne	133	-	-	-	-	133	31	-	-
Totals	**2,175**	**156**	**54**	**121**	**32**	**685**	**201**	**1,213**	**338**
Butler	90	-	-	41	9	49	21	-	-
Cape Girardeau	110	-	-	44	11	66	22	-	-

Figure 3.183. State-owned Facilities with Potential Earthquake Damages Moderate and Above based on Ground Shaking with a 2% Probability of Exceedance in 50 years



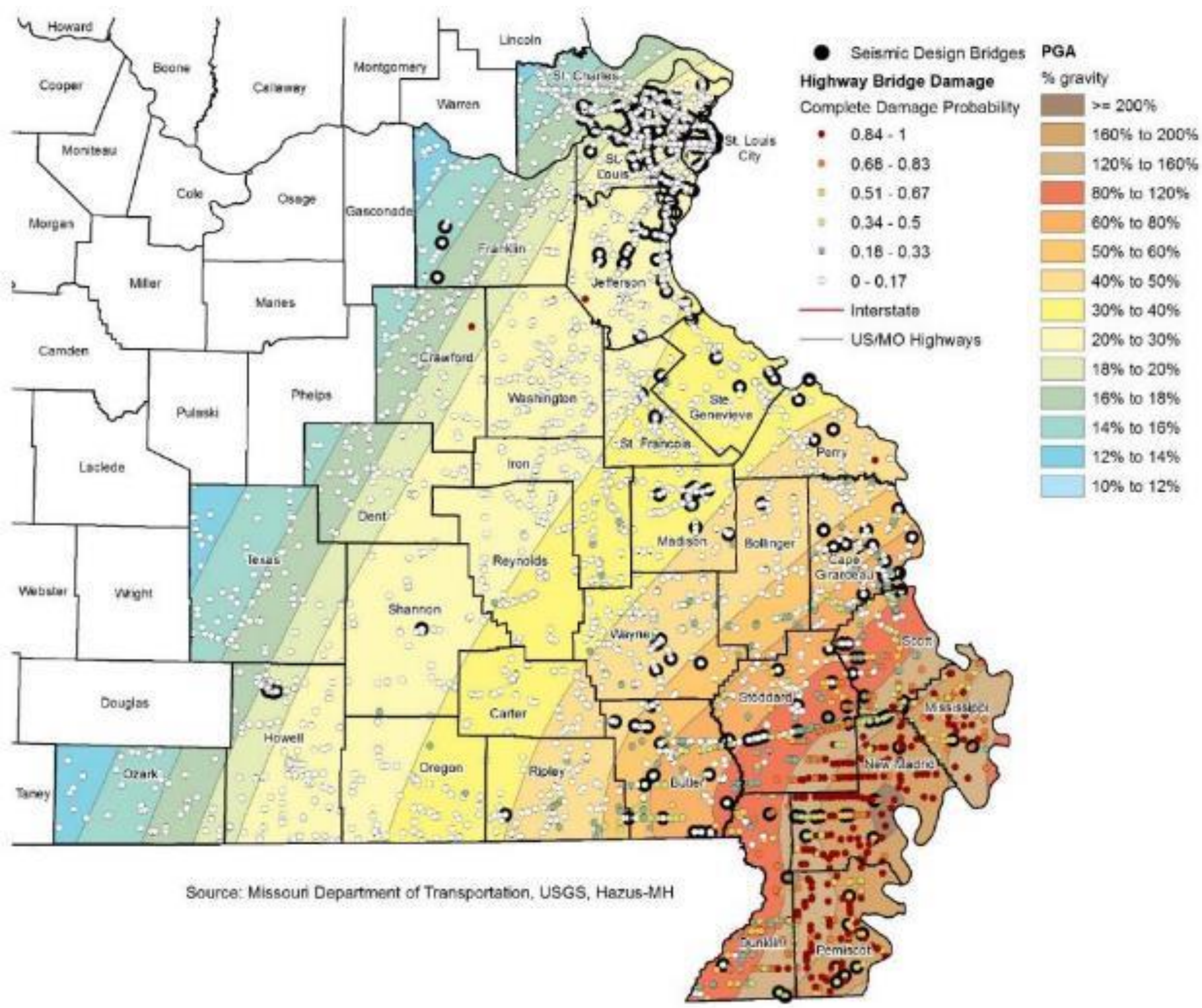
During the 2017-18 update an enhanced analysis was performed for bridges, hazardous materials facilities and essential facilities (schools, fire and medical facilities) to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. Default Hazus inventories for bridges were replaced with data supplied by MoDOT. The results are detailed in Appendix C. In addition to the analysis of facilities from the Office of Administration and the Department of Higher Education that were available in GIS format, the State analyzed information provided by the Missouri Department of Transportation regarding state-owned bridges. It should be noted that MoDOT considers risk to seismic activity in the design and construction of all new bridges in Missouri. In addition, as older bridges are retrofitted, MoDOT considers incorporation of seismic design standards. This analysis does not differentiate those bridges that have been seismically retrofitted or built to modern design standards.

Table 3.124 provides the counts of state-owned bridges by PGA range according to the seismic event with a 2% probability of exceedance in 50 years. The table below summarizes the average damage probability for bridges by county for high-risk counties. Counties where over 50% of the bridges are likely to be completely damaged are highlighted in the table. This includes Dunklin, New Madrid, Mississippi, and Pemiscot counties. **Figure 3.184** provides the locations of the bridges in critical counties with sorted in PGA Ranges.

Table 3.124. State-owned Bridges Earthquake Potential Damages 2% in 50 Years Scenario

Counties	Average for Damage State					
	Bridge Counts	None	Slight	Moderate	Extensive	Complete
Bollinger	65	0.56	0.17	0.09	0.1	0.08
Butler	136	0.39	0.16	0.13	0.14	0.18
Cape Girardeau	147	0.5	0.17	0.11	0.12	0.11
Carter	43	0.71	0.13	0.07	0.05	0.04
Crawford	86	0.88	0.06	0.03	0.01	0.02
Dent	60	0.83	0.09	0.04	0.03	0.01
Dunklin	110	0.11	0.09	0.1	0.18	0.52
Franklin	134	0.86	0.07	0.04	0.02	0.01
Howell	123	0.87	0.07	0.03	0.02	0.01
Iron	80	0.76	0.12	0.05	0.04	0.03
Jefferson	189	0.78	0.09	0.06	0.04	0.03
Madison	67	0.68	0.15	0.07	0.06	0.04
Mississippi	61	0.04	0.06	0.06	0.15	0.7
New Madrid	148	0.03	0.04	0.04	0.11	0.77
Oregon	58	0.72	0.14	0.06	0.05	0.03
Ozark	46	0.82	0.09	0.04	0.03	0.02
Pemiscot	135	0.02	0.04	0.05	0.12	0.76
Perry	51	0.62	0.14	0.1	0.07	0.07
Reynolds	64	0.75	0.12	0.06	0.04	0.03
Ripley	70	0.61	0.14	0.08	0.09	0.08
Scott	99	0.19	0.13	0.13	0.17	0.38
Shannon	43	0.72	0.12	0.07	0.05	0.03
St. Charles	199	0.88	0.06	0.04	0.01	0.01
St. Francois	87	0.75	0.12	0.07	0.04	0.03
St. Louis	165	0.86	0.07	0.04	0.02	0.02
St. Louis City	468	0.85	0.07	0.04	0.02	0.01
Ste. Genevieve	64	0.71	0.12	0.08	0.06	0.04
Stoddard	188	0.19	0.14	0.1	0.17	0.41
Texas	85	0.86	0.07	0.04	0.02	0.01
Washington	95	0.85	0.07	0.04	0.02	0.01
Wayne	121	0.64	0.16	0.08	0.07	0.05

Figure 3.184. MoDOT State-Owned Bridges Damage Probability based on Ground Shaking with a 2% Probability of Exceedance in 50 years



3.5.5. Land Subsidence/Sinkholes

During the 2023 Plan update GIS data was available for sinkholes to determine proximity of State-owned facilities. State Owned and Leased facilities were compared to the sinkhole GIS layer supplied by Missouri Department of Natural Resources (MoDNR), Missouri Geological Survey (MGS), Geological Survey Program (GSP), Environmental Geology Section (EGS). Six facilities, one critical, were located in potential sinkhole hazard areas as summarized in the following table. No state leased, MDC, or MoDOT facilities were identified as potentially vulnerable.

Table 3.125. State Owned Facilities Potentially Vulnerable to Sinkholes

County	# of Facilities	# of Critical Facilities	Value of Structures
Laclede	3	1	$4,375,635
Oregon	3	0	$123,941
Total	6	1	**$4,499,576**

3.5.6. Drought

Structures that are part of the State-owned facility inventory are not directly vulnerable to losses as a result of drought. However, the shrink-swell cycle that occurs as soils swell during wet periods and shrink during drought periods can cause damage to MoDOT roads and bridges as well as other concrete components, and structure foundations. In Missouri, the majority of impacts associated with drought are to the agricultural sector, not facilities. However, the conservation areas owned and operated by the Missouri Department of Conservation would be impacted as streams, lakes, and ponds can shrink in size or completely dry up causing death to fish and other wildlife and loss of recreation-based revenue. Another potential vulnerability could be state-owned fish hatcheries.

3.5.7. Extreme Temperatures

The vulnerability of state-owned or leased buildings or facilities to extreme temperatures is difficult to quantify. Extreme cold can sometimes result in burst water pipes if mitigative measures are not taken, which can result in water damage. Extreme heat does not typically impact buildings but does place additional stress on HVAC components. Asphalt parking lots and roads are routinely damaged during periods of extreme heat as the hot asphalt becomes less rigid and can be displaced by heavy equipment or automobiles.

3.5.8. Severe Thunderstorms (includes damaging winds, hail and lightning)

The counties in **Table 3.126** below are those counties that received a High or Medium-High vulnerability rating for Severe Thunderstorms. The table provides the total number of state-owned facilities in these counties as well as the number of facilities determined to be critical and the total replacement value. Potential annualized damages were determined utilizing the annualized loss ratios for high wind, hail, and lightning as developed in **Section 3.3.8.** Information is also provided for the number of state-leased facilities in these counties and the number of leased facilities determined to be critical.

Table 3.126. State-owned and Leased Facilities in Counties with High and Medium-High Vulnerability to Severe Thunderstorms

Thunderstorm	County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Potential Annualized Damages	Total Leased Facilities	Critical Leased Facilities
Medium High	Barry	96	24	$27,426,320	$1,888.16	7	5
Medium High	Boone	81	23	$17,625,833	$25.81	21	17
Medium High	Cape Girardeau	110	33	$54,559,504	$1,892.43	25	22
Medium High	Christian	24	10	$2,382,005	$137.38	8	7
Medium High	Douglas	1	0	$192,684	$45.57	3	3
High	Greene	97	24	$100,674,983	$2,316.94	38	17
Medium High	Howell	19	9	$7,421,349	$343.48	13	13
High	Jackson	221	50	$237,568,751	$2,407.38	50	29
High	Jasper	52	15	$30,675,768	$713.04	15	14
Medium High	Jefferson	98	32	$34,995,498	$14.10	15	12
Medium High	Laclede	71	22	$23,515,774	$734.61	12	10
Medium High	Newton	13	0	$9,153,594	$282.86	7	7
Medium High	Ozark			$0	$0.00	3	2

Thunderstorm	County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Potential Annualized Damages	Total Leased Facilities	Critical Leased Facilities
High	St. Charles	69	24	$54,410,961	$10,542.69	20	18
High	St. Louis	457	103	$384,787,865	$92,653.81	25	16
Medium High	St. Louis City	167	42	$434,254,891	$585.78	44	11
Medium High	Stone	6	3	$907,052	$42.49	6	5
Medium High	Taney	28	11	$4,989,562	$84.95	11	9
	Total	**1,610**	**425**	**$1,425,542,397**	**$114,711**	**323**	**217**

MoDOT has 92 (44 critical) facilities within the High or Medium-High vulnerability rated counties; MDC has 405 (50 critical) facilities worth $43M, and DHE has 243 facilities worth $1.5B exposed in counties most vulnerable to thunderstorms.

3.5.9. Severe Winter Weather

The counties in **Table 3.127** below are those counties that received a High or Medium-High vulnerability rating for Severe Winter Weather. The table provides the total number of state-owned facilities in these counties as well as the number of facilities determined to be critical and the total replacement value. Information is also provided for the number of state-leased facilities in these counties and the number of leased facilities determined to be critical.

Table 3.127. State-owned and Leased Facilities in Counties with High Vulnerability to Severe Winter Weather

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Total Leased Facilities	Critical Leased Facilities
Butler	90	30	$45,657,256	11	10
Camden	231	38	$23,944,431	13	9
Cape Girardeau	110	33	$54,559,504	25	22
Clay	37	15	$17,284,344	14	12
Dunklin	8	2	$4,331,627	9	9
Franklin	136	42	$85,414,212	7	6
Greene	97	24	$100,674,983	38	17
Jackson	221	50	$237,568,751	50	29
Mississippi	66	29	$96,600,383	5	4
New Madrid	45	15	$8,581,408	6	6
Pemiscot	0	0	$0	7	7
Ripley	14	5	$5,199,536	2	1
Scott	45	10	$19,982,660	13	13
St. Charles	69	24	$54,410,961	20	18
St. Louis	457	103	$384,787,865	25	16
St. Louis City	167	42	$434,254,891	44	11

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Total Leased Facilities	Critical Leased Facilities
Stoddard	28	10	$10,833,446	7	6
Wayne	133	31	$34,142,496	2	2
Total	**1,954**	**503**	**$1,618,228,755**	**298**	**198**

3.5.10. Tornadoes

The counties in **Table 3.128** below are those counties that received a High vulnerability rating for Tornadoes. The table provides the total number of state-owned facilities in these counties as well as the number of facilities determined to be critical and the total replacement value. Information is also provided for the number of state-leased facilities in these counties and the number of leased facilities determined to be critical.

Table 3.128. State-owned and Leased Facilities in Counties with High Vulnerability to Tornadoes

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Total Leased Facilities	Critical Leased Facilities
Barry	96	24	$27,426,320	7	5
Butler	90	30	$45,657,256	11	10
Clay	37	15	$17,284,344	14	12
Greene	97	24	$100,674,983	38	17
Howell	19	9	$7,421,349	13	13
Jackson	221	50	$237,568,751	50	29
Jasper	52	15	$30,675,768	15	14
Newton	13	0	$9,153,594	7	7
St. Charles	69	24	$54,410,961	20	18
St. Louis	457	103	$384,787,865	25	16
St. Louis City	167	42	$434,254,891	44	11
Total	**1,318**	**336**	**$1,349,316,083**	**244**	**152**

3.5.11. Wildfires

During the 2023 Plan update an analysis was performed to identify state facilities within a high interface or high intermix wildland fire zone based on the SILVIS hazard data. These are summarized in the table that follows. There were not any DHE or MODOT facilities identified in a high wildland fire hazard zone.

Table 3.129. Facilities Within a High Wildfire Hazard Zone

SILVIS Fire Hazard	County	# of Facilities	# of Critical Facilities	Value of Structures
Owned Facilities				
High_Interface	Adair	6	1	$4,316,299
High_Interface	Camden	4	1	$795,906
High_Interface	Gasconade	7	3	$1,222,028
High_Interface	Grundy	19	6	$1,738,388
High_Interface	Jefferson	6	5	$3,919,152
High_Interface	Johnson	18	5	$4,370,467
High_Interface	Platte	12	5	$2,107,134
High_Interface	St. Francois	8	5	$6,303,135
	SubTotal	**80**	**31**	**$24,772,510**
Leased Facilities				
High_Interface	Adair	1	1	---
High_Interface	Buchanan	11	0	---
High_Interface	Crawford	1	1	---
High_Interface	Franklin	1	1	---
High_Interface	Wayne	1	1	---
	SubTotal	15	4	---
MDC Facilities				
High_Interface	Texas	2	1	---
	SubTotal	2	1	---

Source: Wood E&IS 2017

3.5.12. Scour Critical Bridges

The State analyzed information provided by the Missouri Department of Transportation regarding scour critical state-owned bridges. Scour critical bridges are those bridges that are vulnerable to scour during a flood. Bridge scour is the removal of sediment such as sand and rocks from around bridge abutments or piers. Scour is caused by swiftly moving water and can scoop out scour holes, compromising the integrity of the bridge. The National Bridge Inventory uses a classification system of 0-3 to indicate the potential for scour. Bridges in the 0-1 categories are those that are at or near failure due to scour; those in the 2-3 categories are vulnerable to scour and determined to be unstable. There are a total of 221 scour critical bridges that are a category 3 out of the inventory of 10,400 total state-owned bridges. There are no category

0-2 bridges in the inventory. **Table 3.130** provides the counts of state-owned bridges with the scour rating of 3. **Figure 3.185** provides the locations of these bridges across the State.

Table 3.130. Count of State-owned Scour Critical Bridges

Scour Class	# of Bridges	Value of Bridges
3	221	$631,749,685

Figure 3.185. MoDOT State-Owned Flood Scour Critical Bridges

Source: MoDOT, National Bridge Inventory - State Owned

3.5.13. Civil Disorder

Civil disorder can occur at random times and locations. As a result, it is difficult to specify state-owned or operated facilities that may be impacted by this hazard. Incarcerated populations can be more prone to civil disorder as a concentrated group of high-risk individuals. Therefore, the State-owned correctional facilities with incarcerated populations could be considered to be at higher risk to civil disorder than other state-owned facilities. There are 190 state-owned facilities that were identified as areas where groups of incarcerated individuals are located at times. There were no state-leased facilities with incarcerated populations at the site. The state-owned facilities with incarcerated populations are located in the following Missouri counties in **Table 3.131**.

Table 3.131. State-owned Facilities with Incarcerated Populations

County	# of Facilities w/ Incarcerated Persons
Audrain	6
Buchanan	4
Callaway	12
Clark	13
Cole	34
DeKalb	21
Dunklin	12
Franklin	14
Gentry	6
Howard	13
Laclede	9
Livingston	6
Marion	1
Mississippi	7
Nodaway	1
Randolph	5
St. Francois	14
St. Louis	4
St. Louis City	1
Webster	6
Worth	1
Total	**190**

3.5.14. Cyber Disruptions

Data is not available to quantify vulnerability or estimated losses as a result of cyber disruption incidents that might impact state-owned facilities. Any state-owned/operated facility that uses computers to provide services/conduct business is at risk to cyber disruption incidents, whether intentional or accidental. In Missouri, the Information Technology Services Division (ITSD), which is part of the Office of Administration

(OA), provides direct IT support to nearly all the state government agencies that are under the umbrella of Missouri's 14 IT-consolidated departments. During the 2016 legislative session, ITSD received additional ongoing funding for cyber security from Governor Nixon and the General Assembly. These funds are being used by ITSD's team of cyber security professionals as they enhance the state's cyber security systems and train state employees in cyber security best practices. Within ITSD, the Office of Cyber Security (OCS) is responsible for managing all cyber security related events within the enterprise and ensuring proper administrative and technical controls are implemented to safeguard the State of Missouri's information system (State of Information Technology in Missouri, 2015, https://oa.mo.gov/information-technology-itsd).

According to the Information Technology Services Division, during an average month, the state's intrusion prevention system blocks over two million attacks. In early 2015, the OCS developed a threat intelligence (intel) sharing portal for internal state staff and associated business partners with the state. The portal enables OCS to share threat intel to others quickly and effectively. The portal is meant to raise awareness throughout the state community about the adversaries the state faces and to provide meaningful and actionable intel so others can quickly protect themselves from similar attacks. Since the launch of this portal, OCS has shared over 1,200 pieces of intelligence.

Cyber impacts on State and national infrastructure organizations such as utility companies which provide critical services could cause widespread impacts. It is reported that the deregulated energy market may be most susceptible to cyber impacts. Power supply impacts have been noted in a variety of national studies and were common in news reports in the past number of years. It should be noted that many utilities are working to increase infrastructure security to reduce these risks.

3.5.15. Environmental Health Emergencies

An environmental health emergency could provide a primary impact to the state, such as impacts to air quality. A severe event could have an impact to a widespread segment of the population and could remain a threat for a long period of time. The Missouri Department of Natural Resources would be heavily involved in response to an environmental event. Many State agencies and programs exist to help citizens and businesses prepare for and reduce risk. Other incidents that would have an environmental impact would be terrorist attacks using nuclear, biological or chemical materials. The results from even minor incidents of these types would have large impacts on the surrounding environment and could indirectly impact state facilities.

3.5.16. Hazardous Materials Release (Fixed Facility Accidents)

Risk to state facilities was modeled by a GIS buffer analysis to determine state facilities within 0.5 miles of a Tier II hazardous materials facility.

Table 3.132 summarizes the State-owned facilities within 0.5 miles of Tier II hazardous materials facilities, followed by a table summarizing state-leased facilities. The analysis shows that a large number of facilities are in the buffer zone, 4,892 total. An additional 402 DHE, 176 MDC and 205 MoDOT facilities are within the buffer zone.

Table 3.132. State-owned facilities within 0.5 miles of Tier II hazardous Materials Facilities

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Adair	48	14	$12,899,746
Audrain	54	23	$103,076,942

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Barry	22	4	$4,321,457
Barton	14	3	$1,200,037
Bates	10	1	$2,253,465
Benton	12	5	$1,289,344
Boone	31	8	$3,365,371
Buchanan	183	74	$247,584,100
Butler	52	20	$23,448,654
Callaway	185	68	$574,219,287
Camden	64	11	$5,701,399
Cape Girardeau	56	17	$22,150,403
Cass	18	4	$5,779,256
Cedar	11	3	$824,231
Clinton	9	5	$2,063,177
Cole	413	103	$894,236,594
Cooper	102	43	$84,150,588
Crawford	43	10	$6,354,088
Dade	7	5	$3,969,521
Dallas	14	2	$2,582,074
DeKalb	56	28	$126,385,640
Dent	44	7	$8,982,027
Dunklin	7	2	$4,308,493
Franklin	70	28	$75,457,425
Gasconade	12	3	$2,337,014
Gentry	15	5	$8,188,639
Greene	61	17	$63,382,969
Grundy	38	11	$6,744,406
Henry	29	9	$8,596,619
Hickory	3	1	$235,562
Holt	12	5	$2,073,706
Howard	6	1	$1,952,651
Howell	8	3	$3,395,451
Iron	3	1	$203,449
Jackson	165	39	$217,865,090
Jasper	33	7	$21,147,998
Jefferson	48	17	$21,757,587
Johnson	70	19	$42,388,800

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Laclede	53	17	$18,649,444
Lafayette	113	34	$79,366,445
Lawrence	33	8	$42,554,063
Lewis	9	3	$598,548
Lincoln	34	11	$10,187,123
Linn	10	5	$1,457,059
Livingston	15	6	$6,024,152
Macon	41	10	$13,474,858
Madison	9	3	$3,474,361
Marion	46	12	$15,430,739
McDonald	3	2	$0
Miller	52	31	$11,531,622
Mississippi	45	27	$94,597,343
Moniteau	56	29	$72,229,165
Monroe	18	6	$2,518,436
Montgomery	52	12	$16,056,755
New Madrid	17	6	$3,525,948
Newton	13	0	$9,153,594
Nodaway	33	16	$31,830,131
Oregon	8	2	$77,326
Pettis	150	25	$145,723,080
Phelps	85	26	$57,055,414
Pike	61	29	$133,656,408
Platte	17	6	$2,417,081
Randolph	13	4	$6,288,223
Ray	69	7	$17,337,203
Ripley	14	5	$5,199,536
Saline	143	29	$150,195,818
Scott	25	6	$12,055,081
St. Charles	23	8	$33,343,100
St. Francois	174	80	$278,552,455
St. Louis	192	45	$193,021,020
St. Louis City	143	36	$366,058,092
Ste. Genevieve	29	9	$4,294,784
Stoddard	9	5	$3,789,415
Stone	6	3	$907,052

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Taney	28	11	$4,989,562
Texas	46	25	$105,927,386
Vernon	92	17	$22,925,185
Warren	6	1	$3,775,388
Washington	25	13	$74,679,183
Webster	54	22	$38,962,063
Total	**4,092**	**1,278**	**$4,710,762,906**

Table 3.133. State –leased Facilities within 0.5 miles of Tier II hazardous Materials Facilities

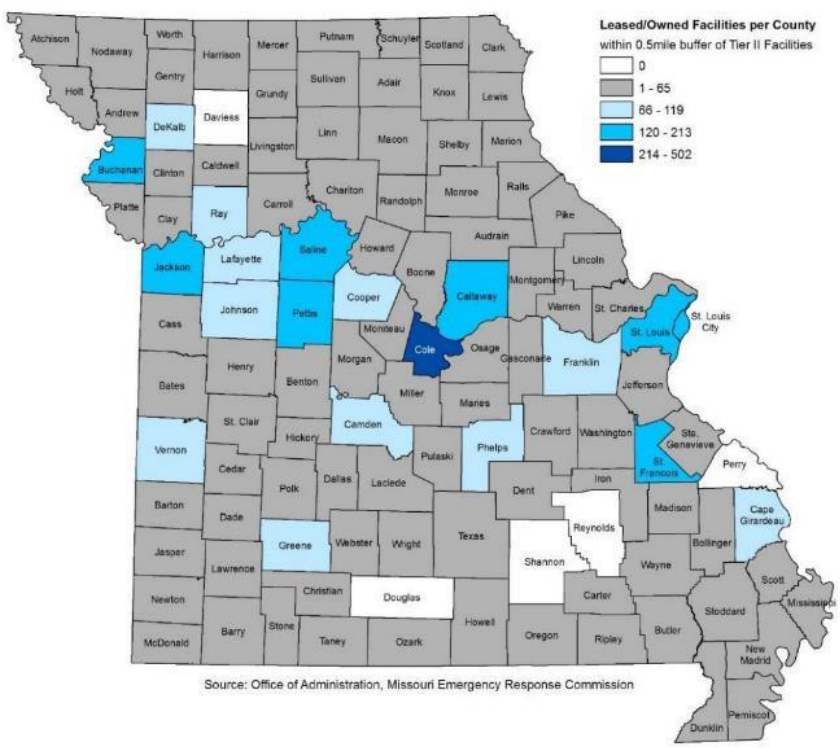
County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Adair	5	5	$153,385
Andrew	2	2	$12,401
Atchison	6	4	$60,107
Audrain	4	4	$62,856
Barry	5	4	$101,940
Barton	4	3	$64,654
Bates	6	5	$111,758
Benton	5	5	$52,807
Bollinger	4	4	$32,826
Boone	18	17	$1,609,959
Buchanan	14	2	$268,775
Butler	11	10	$455,552
Caldwell	5	5	$35,433
Callaway	6	3	$158,607
Camden	13	9	$284,668
Cape Girardeau	20	18	$1,381,610
Carroll	3	3	$41,730
Carter	1	1	$0
Cass	6	6	$222,572
Cedar	4	4	$51,063
Chariton	3	3	$27,179
Christian	6	5	$107,103
Clark	4	3	$59,566
Clay	12	11	$662,211
Clinton	1	1	$0

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Cole	89	44	$7,628,082
Cooper	5	4	$55,100
Crawford	5	5	$74,578
Dade	4	4	$7,295
DeKalb	12	10	$169,588
Dent	4	4	$124,344
Dunklin	8	8	$280,912
Franklin	5	5	$330,138
Gasconade	2	2	$18,819
Gentry	1	1	$0
Greene	34	16	$2,191,013
Grundy	6	5	$111,564
Harrison	7	5	$54,636
Henry	7	7	$121,540
Hickory	3	3	$41,591
Holt	3	3	$12,820
Howard	3	3	$45,501
Howell	3	3	$64,181
Iron	3	3	$41,101
Jackson	45	25	$2,643,641
Jasper	14	14	$772,556
Jefferson	8	8	$372,525
Johnson	9	6	$282,675
Knox	2	2	$4,450
Laclede	11	9	$226,439
Lafayette	6	5	$115,368
Lawrence	6	5	$131,402
Lewis	3	3	$29,207
Lincoln	5	5	$160,459
Linn	4	4	$59,285
Livingston	10	9	$114,658
Macon	9	8	$358,444
Madison	4	4	$55,576
Maries	2	2	$14,740
Marion	6	4	$127,028
McDonald	5	5	$79,589

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Mercer	3	3	$19,265
Miller	6	5	$140,875
Mississippi	4	3	$127,066
Moniteau	2	2	$6,761
Monroe	2	2	$35,221
Montgomery	3	3	$41,580
Morgan	2	2	$12,566
New Madrid	6	6	$122,253
Newton	6	6	$243,195
Nodaway	3	3	$26,671
Oregon	4	3	$58,517
Osage	2	2	$21,714
Ozark	3	2	$65,568
Pemiscot	7	7	$267,566
Pettis	9	8	$310,849
Phelps	8	8	$312,037
Pike	4	4	$59,938
Platte	5	5	$121,594
Polk	7	7	$73,408
Pulaski	8	7	$139,128
Putnam	3	3	$18,824
Ralls	3	3	$11,262
Randolph	6	6	$154,633
Ray	4	4	$62,566
Ripley	2	1	$16,913
Saline	5	5	$546,227
Schuyler	2	2	$7,222
Scotland	4	4	$88,577
Scott	13	13	$406,691
Shelby	3	3	$31,706
St. Charles	16	16	$1,017,068
St. Clair	3	2	$11,727
St. Francois	7	7	$355,003
St. Louis	21	13	$961,286
St. Louis City	43	10	$2,967,445
Ste. Genevieve	4	4	$25,896

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Stoddard	5	4	$142,026
Sullivan	3	3	$28,988
Taney	3	1	$23,440
Texas	1	1	$608
Vernon	11	11	$680,099
Warren	3	3	$73,275
Washington	5	5	$134,030
Wayne	1	1	$3,232
Webster	6	6	$77,530
Worth	2	2	$11,307
Wright	6	6	$159,226
Total	**800**	**617**	**$33,162,175**

Figure 3.186. State Facilities Within 0.5 Miles of a Tier II Facility



3.5.17. Mass Transportation Accidents

Transportation accidents do not impact state-owned facility building structures; however, they can impact state-owned roads and bridges. Roads are not typically damaged by transportation accidents. But bridge railings and other structures can sustain damages. Data is not available to estimate future damages.

3.5.18. Nuclear Power Plants (Emergencies and Accidents)

Table 3.134 below lists the facilities within a 10-mile radius of the two nuclear power plants (Callaway and Cooper) that could impact Missouri in the event of an emergency or accident. This table provides counts and values of state-owned facilities as well as counts of state-leased facilities.

Table 3.134. State-owned and Leased Facilities in Counties within 10-mile Radius of Nuclear Power Plants

County	Total State-owned Facilities	Critical State-owned Facilities	Total State-leased facilities	State-leased Critical Facilities	Value of Structures
Atchison	0	0	4	3	---
Callaway	91	41	NA	NA	$141,257,569
Montgomery	3	2	0	0	$151,926

3.5.19. Public Health Emergencies

State-owned facilities are not directly impacted by this hazard. However, the Missouri Department of Health and Senior Services would be heavily involved in response to a pandemic incident. A research review was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The review showed that while state-owned facilities are not directly impacted by this hazard, the citizens and communities in which these facilities reside could be directly and indirectly impacted. The information determined to be of significance is provided below.

First, a public health incident could provide a primary impact; the most common and most recent experience would be that of a severe or pandemic influenza event. A severe event could have an impact to a widespread segment of the population and could remain a threat for a long period of time. The Missouri Department of Health and Senior Services would be heavily involved in response to a pandemic incident. Many State agencies and programs exist to help citizens and businesses prepare for and reduce transmission risks. Medical information is available, particularly during flu season and at all times citizens are encouraged to create family plans, and to keep informed on current events that may impact them and their homes. Other incidents that would have a public health impact would be terrorist attacks using nuclear, biological or chemical materials. The results from even minor incidents of these types would have large impacts on the surrounding environment and could indirectly impact state facilities.

Secondly, a review of available information does show that a public health emergency could emerge as the result of another incident or event. For example, poor sanitary conditions and the lack of sanitation in the aftermath of a weather-related event such as a hurricane or tornado could lead to an increase in waterborne illness or more serious impacts. Critical to the recovery process is ensuring that public health issues are immediately addressed to reduce the risk of such incidents occurring.

3.5.20. Special Events

Data is not available to quantify vulnerability or estimated losses as a result of incidents at special events. However, special events do occur at state-owned facilities on an ongoing basis. The State of Missouri is home to thirteen public universities. In addition, there are thirty-nine private four-year institutions in the state.

These universities host special events regularly throughout the year. These include athletic events, visits from high-profile individuals and large gatherings like graduations. These occurrences are generally open to the public, and thus can expose a large number of people to a potential event.

In addition to the universities within the state, Missouri is home to multiple professional sports teams. While the teams are privately owned, many of the stadiums in which they play receive public funds. These teams generally draw crowds in the tens of thousands. These large crowds are drawn into public areas, and can expose the attendees to a variety of hazards. The Scottrade Center (Home to the St. Louis Blues) is an enclosed arena, and can help protect attendees from weather-related events like thunderstorms, winter storms, etc. Busch Stadium (home to the St. Louis Cardinals) is an open-air stadium; this leaves attendees exposed to the potential weather hazards like thunderstorms, excessive heat and high wind events.

Regardless of the venue, or the time of year, large public gatherings will leave attendees susceptible to a variety of hazards. Attendees can be susceptible while traveling to and from these events. Special events present a strain to community and state resources by their very nature. The addition of a weather-related or other hazard can serve to exacerbate the situation.

3.5.21. Terrorism

Data is not available to quantify vulnerability or estimated losses as a result of terrorism incidents that might impact state-owned facilities. However, a research investigation was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The information determined to be of significance is provided below.

Chemical Terrorist Attack (Non-Food) is applicable for the State of Missouri. The potential for impact for the State of Missouri would consist of 114 Counties, 961 cities, 9 regions, 69,704 sq/mi and 6,010,688 people. A terrorist attack could impact any portion of the land, population, or any state facility, depending on the scale of the event.

Missouri is home to a wealth of organizations that focus on homeland security and counterterrorism. The state has three fusion centers that gather, analyze, and share intelligence information, and has more than one Joint Terrorism Task Force (JTTF). Two centers, the St. Louis Terrorism Early Warning Group fusion center and the Kansas City Regional TEW Interagency Analysis Center keep inventories of the critical infrastructure and key resources in each region. The critical infrastructure information is protected in order to safeguard the facilities from terrorist attacks. A protective security advisor from the Department of Homeland Security (DHS) is stationed in St. Louis in order to assist the region in protecting critical infrastructure. One of the important functions of the DHS advisor is to conduct building or property security assessments with owners of infrastructure. The state implemented Regional Homeland Security Oversight Committees (RHSOC) that covers the same nine regions as the Highway Patrol Troop. The FBI has field offices in both St. Louis and Kansas City, but also have remote offices scattered throughout the rest of the state (Priest and Arkin, 2013).

Missouri's State Emergency Management Agency (SEMA) has organized a Homeland Security Regional Response System (HSRRS) to improve emergency response to various hazards and build capabilities, including terrorist neutralization as a region. An initiative called Project Homeland has started in Missouri and three other pilot states to collect intelligence and GIS data from various agencies to assist in protecting critical infrastructure in Missouri (Missouri Office of Homeland Security, 2013).

Though state facilities in Missouri are still vulnerable to terrorist attack, the planning mechanisms, organizations, agencies, and resources that are organized within the state help to reduce the overall risk as well as mitigate the impact should an event occur.

3.5.22. Utilities (Interruptions and System Failures)

The primary impact to state-owned facilities as a result of the loss of utilities is the inability to provide continuous state government services. The Office of Administration Facilities Management, Design & Construction (FMDC) manages many of the state-owned facilities in Missouri. The State uses physical and environmental security controls in order to protect their systems from data loss due to utility interruption. State agencies are instructed to maintain battery backup power onsite in addition to a 24-hour fuel supply for power generators if they are present at facilities (MOA, 2007). Another guideline suggests that state facilities should consider providing an uninterruptible power source (UPS) to maintain operations during events (MSU, 2012).

Utility interruptions can occur in any part of the state at any time of year. Harsh weather conditions such as lightning strikes, high winds, heavy rain, and ice storms can cause trees to fall and damage electric power lines and equipment or gas lines. The National Weather Service produces an Ice Impact Index to estimate the potential utility interruptions based on the weather conditions prior to an ice storm. The index ranges from 1 to 5 and increases in severity as it increases in number, estimating that the potential for longer outages increases as the conditions worsen. Though the vulnerability of state- owned facilities has not yet been quantified, it could be estimated for discrete events by using this index (NWS, 2012). Earthquakes are another natural hazard that can lead to utility service interruption. The same state facilities vulnerable to earthquakes are also vulnerable to utility interruption or failure. See **Section 3.3.4** for Earthquake Facility Vulnerability.

In Macon, Missouri, part of their combined heat and power system (CHP) can be used to disconnect from the local grid if there is an outage in order to continue running an ethanol plant. The system is owned and operated by the City and has kept the plant running during recent outages (USCHPA, 2010).

SEMA has emergency generators that they can loan out to critical state or private facilities as needed during events. This reduces the overall vulnerability of facilities when they can rely on back-up power sources until the main systems are restored (SEMA, 2013).

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4 Comprehensive State Hazard Mitigation Program

4. Comprehensive State Hazard Mitigation Program

This section describes the State's Comprehensive State Hazard Mitigation Program including the hazard mitigation goals and objectives that frame and focus the mitigation strategy, mitigation actions and strategy for reducing repetitive flood losses, funding sources, the State capability assessment to implement the mitigation strategy, and the local capability assessment.

4.1. Hazard Mitigation Goals

Requirement §201.4(c)(3)(i): [The state mitigation strategy shall include a] description of state goals to guide the selection of activities to mitigate and reduce potential losses.

Plan Update Requirement §201.4(d): [The] plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts and changes in priorities.

The purpose of this section is to describe the goals and objectives of the state mitigation program. In order to be effective, these goals and objectives must be achievable, and they must complement both state and local mitigation strategies. They also play a role in the State's overall mitigation strategy through a balanced review and prioritization of proposed mitigation projects.

The results of these mitigation efforts are important to state and local governments, public-private partnerships, and the general public. By establishing reasonable goals and objectives, those involved in the planning process can see their efforts realized which can make a difference in other mitigation efforts.

Section 4.1.1 identifies the primary goals and objectives for the State's hazard mitigation program in prioritized order. The goals and objectives reflect the mature nature of SEMA's established statewide hazard mitigation program and have evolved over several years of state mitigation planning efforts. SEMA encourages its partners to consider these mitigation goals when developing local mitigation plans and other plans.

4.1.1. State of Missouri Mitigation Goals

Goal 1: Preserve *human life, health, and safety* from the adverse effects of disasters

1.1. Maintain a robust mitigation program that addresses ways to mitigate the ***loss of life*** from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety, and reduce vulnerability to high hazard dams and potential consequences, reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

1.2. Increase public awareness of disaster risks and effective mitigation measures that protect ***human life*** in cooperation with SEMA's mitigation partners.

1.3. Support the development of sensible enabling legislation, programs, and capabilities of federal, state, and local governments and public-private partnerships engaged in mitigation activities.

1.4. Maintain a high level of mitigation proficiency among SEMA staff.

Goal 2: Defend the *continuity of government and essential services and processes* from the adverse effects of disasters

2.1. Support the development of sensible mitigation projects to protect key and ***essential facilities and services***.

2.2. Continue to educate federal, state, and local public officials; educational institutions; private associations; and private business entities that provide ***essential services*** about hazards and how mitigation can reduce losses and help maintain continuity.

2.3. Educate state and local officials concerning the need to use sensible mitigation techniques for new facility construction.

2.4. Encourage maximum participation in maintaining effective state and local mitigation plans, disaster plans, and business continuity plans.

2.5. Encourage federal, state, and local officials; educational institutions; private associations; and private business entities that provide essential services to incorporate mitigation into other plans.

Goal 3: Protect *public and private property* from the adverse effects of disasters

3.1. Maintain an effective mitigation program that addresses ways to mitigate the ***loss of property*** from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety and reduce vulnerability to high hazard dams and potential consequences, reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

3.2. Increase public awareness of disaster risks and effective mitigation measures that protect ***public and private property*** in cooperation with SEMA's mitigation partners.

3.3. Support organizations that work to help mitigate the adverse effects of disasters.

3.4. Support the National Flood Insurance Program, Community Rating System (CRS), earthquake insurance, and other programs that serve to reduce the impacts of disasters on properties.

Goal 4: Safeguard *community tranquility* from the adverse effects of disasters

4.1. Develop, implement, and complete mitigation projects as expeditiously, effectively, efficiently, and unobtrusively as possible.

4.2. Consider sustainability issues (ecologically sound, economically viable, socially just, and humane) when developing or reviewing mitigation projects and plans.

4.3. Lead and support the work of mitigation partners to educate the general public about how mitigation can help protect communities and promote ***community tranquility***.

4.4. Develop and provide periodic reports and success stories to federal, state, and local public officials, educational institutions, private associations, private business entities, and the public on the progress of hazard mitigation activities.

4.5. Encourage citizens and citizen organizations to support and use mitigation in plans, projects, and public outreach to increase a sense of community security and safety.

4.1.2. Process for Identifying, Reviewing, and Updating State Goals and Objectives

Missouri's SRMT developed the goals and objectives to guide the state mitigation program and the selection of actions to mitigate potential losses from hazard events. The goals and objectives represent a long-term vision for hazard reduction and enhancement of mitigation capabilities and have evolved over years of mitigation planning in Missouri.

During the 2023 update process, the goals and objectives from the 2018 plan were reviewed to determine if they still address current conditions and anticipated future needs. This was accomplished during the first and fifth planning meeting. The SRMT assessed the goals and objectives based on the process outlined in **Section 6.2.3** Monitoring Progress for Mitigation Goals, Objectives, and Activities. In addition to that process, the review was based on:

- The 2023 updated statewide risk assessment, which includes changes in growth and development, recent disasters, enhanced vulnerability assessments, and analysis of local risk assessments. The key issues identified in the statewide risk assessment and the analysis of local risk assessments can be found in **Section 3** Risk Assessment.
- Assessment of changes and challenges in state and local capabilities since the 2018 plan. Information on the changes in state and local mitigation capabilities is summarized in **Sections 4.5** State Capability Assessment and 4.6 Local Capability Assessment.
- Identification of achieved mitigation objectives from the 2018 plan. **Section 4.2** Mitigation Actions includes detailed and updated mitigation measures designed to meet the designated goals and objectives and progress on these objectives is evaluated in **Sections 4.2** and **Section 7.5** Effective Use of Available Mitigation Funding.

The SRMT concluded that the goals and objectives from the 2018 plan remain valid for the 2023 plan update and continue to guide the State's mitigation philosophy.

4.2. Mitigation Actions and Objectives

Requirement §201.4(c)(3)(iii): [State plans shall include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section should be linked to local plans, where specific local actions and projects are identified.

Plan Update Requirement §201.4(d): Plans must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts and changes in priorities.

This section introduces the mitigation action categories considered by the State to meet the goals and objectives of this plan. Each category is listed, followed by background on how they were identified and prioritized. This section also describes how the action categories were reviewed during the 2023 update to reflect changes in risk, progress in statewide mitigation efforts, and changes in priorities. It further describes the progress of implementation for those mitigation actions and concludes with an analysis of local mitigation actions summarized from the available local mitigation plans including the challenges associated with implementing them.

4.2.1. Objectives of Mitigation Actions in Missouri

There are 14 action categories that SEMA and the SRMT have identified to fulfill this plan's goals and objectives. These action categories must comply with all federal and state requirements for mitigation funding, which means they must be cost-effective, environmentally sound, and technically feasible. The action categories listed below are the primary ones the State supports for addressing the hazards analyzed in this plan (which is not an all-inclusive list). This is followed by a brief description of the types of projects associated with each action category.

- M1—State and Local Hazard Mitigation Plans
  (required to qualify for mitigation funding)
- M2—National Flood Insurance Program Floodplain Management and
  Community Rating System
- M3—Risk Communication
- M4—Voluntary Property Acquisitions (Flood Buyout)
- M5—Voluntary Elevation, Relocation, Floodproofing
- M6—Tornado Safe Rooms
- M7—Earthquake/High Wind Structural and Non-Structural Mitigation Projects
- M8—Wildfire Mitigation Projects
- M9—Structural/Infrastructure Mitigation Projects
  (including Public Assistance projects)
- M10— Response and Recovery Facility Mitigation Projects
- M11— State Owned/Operated Facility Mitigation Projects
- M12—Buried Electric Service Lines
- M13—State 5% Initiative Projects
- M14—Technical Assistance

Mitigation Action Categories with Project Descriptions

M1—State and Local Hazard Mitigation Plans

This includes activities related to mitigation planning at the State and local level and includes completing remaining local mitigation plans and updating existing plans, developing or revising guidance (as appropriate), and providing training.

M2—National Flood Insurance Program Floodplain Management and Community Rating System

This category includes promotion of participation in the National Flood Insurance Program (NFIP) and the wise use of floodplains. Activities can include floodplain management workshops, flood insurance promotion, community assistance visits, floodplain map modernization activities, streambank stabilization, and minor flood control. Communities willing to exceed the minimum NFIP regulations, particularly those with large policy bases, are encouraged to join the Community Rating System. SEMA's Recovery Division, Floodplain Management Section provides information on the NFIP on the following website: https://sema.dps.mo.gov/programs/floodplain/

M3—Risk Communication

Added during the 2023 State Plan Update, this category includes activities related to the communication of information to the communities and citizens of Missouri who are at risk of exposure to hazards. Risk communication activities build risk awareness and understanding at the local level and can include preventative measures addressing development within dam and/or levee inundation areas; outreach measures such as publication and distribution of risk assessment mapping; and coordination efforts with other state, federal or local agencies to exchange hazard and risk information.

M4—Voluntary Property Acquisitions

These projects entail partnering with local entities to buy out properties at risk to flooding. This is SEMA's most important mitigation action, and usually most cost-effective, because the people and property are totally and permanently removed from the path of flooding and danger. SEMA supports acquisitions of residential property and gives priority for funding to residential over commercial property at this time. SEMA's top priorities for acquisition are repetitive flood loss properties and severe repetitive loss properties.

M5—Voluntary Elevation, Relocation, Floodproofing

These projects, in partnership with local entities and property owners, are additional ways to reduce the impacts of flooding. Elevation of flood-prone properties may be used if it is proven to be cost-effective and desirable over the long term (e.g., when the cost of the land is so high that a buyout is impractical). Relocation may be used if it is more practical/cost-effective or when the threat is so severe or has the potential to be repetitive that it is more advantageous to relocate a structure or structures, up to and including entire communities, entirely out of harm's way. Floodproofing may be more feasible in areas of limited danger, particularly for commercial properties (the NFIP does not recognize dry floodproofing for residential structures).

M6—Tornado Safe Rooms

These are projects that protect people from tornadoes and high winds and must also comply with FEMA Publications 320 and 361, which prescribe shelter and safe room construction standards. Projects can range from rooms in non-profit organization (Habitat for Humanity) sponsored homes that protect individual families to large-scale community safe rooms in public buildings and schools. These projects can often meet multiple community objectives, such as a combination school gymnasium/safe room. Safe rooms can also be standalone buildings or internal buildings that are intended to provide protection during a short-term high-wind event, like a tornado. Safe rooms have proven to be successful during these events.

M7—Earthquake/High Wind Structural and Nonstructural Mitigation Projects

This action category was updated to include both structural and non-structural mitigation projects. Structural projects reinforce the structural components of a building to resist seismic and/or high wind loads. There is an emphasis on critical facilities or facilities that would impact life safety if they were to fail due to the hazard. Non-structural projects reduce life safety impacts and, in some cases, can limit damage to nonstructural building elements, such as building utility and lighting systems. Examples include window film and strapping and bracing appliances and fixtures, such as water heaters, shelves, etc.

M8—Wildfire Mitigation Projects

This action category was added to specifically address wildfire mitigation projects. These projects include post-fire mitigation projects for erosion control and watershed protection; ignition resistance construction retrofits for residential properties and infrastructure; defensible space; fuels reduction; and wildfire and post-wildfire warning systems.

M9—Structural/Infrastructure Mitigation Projects (including Public Assistance projects)

These projects develop structures to redirect or modify the impact of a hazard, such as a floodwall, stormwater collection system, or rehabilitation of a dam structure. Public Assistance refers to FEMA's post-disaster program that funds repair or replacement of damaged infrastructure and can sometimes be used for mitigation, depending on the type of damage. An example would be replacing a washed-out culvert with one designed to convey higher flood flows or replacing a cylindrical corrugated pipe with a box culvert. Bridges and low water crossings are other examples that have been funded.

M10—Response and Recovery Facility Mitigation Projects

Added during the 2023 State Plan Update, this category of projects reduces hazard impacts to existing state and local buildings that have been identified as necessary for post-disaster response and recovery operations. Mitigation actions may address flood, wind, earthquake, wildfire, or other hazard events and include such projects as structural reinforcement or relocation.

M11—State Owned/Operated Facility Mitigation Projects

Through the 2023 State Mitigation planning process and improved data capabilities, detailed risk assessments were performed on state owned/operated facilities at risk to dam failure, levee failure, flood, earthquake, sinkholes, wildfire, and hazardous materials. Projects within this category reduce the newly defined hazard impacts to existing state owned and operated facilities.

M12—Buried Electric Service Lines

These projects mitigate utility outages and repair costs from severe weather events such as ice storms, high winds, and tornadoes.

M13—State 5% Initiative Projects

These projects are those that are worthwhile but difficult to prove cost-effective and refer to the five percent of Hazard Mitigation Grant Program funds that, following a disaster, can be set aside for projects such as development of community outreach programs and materials, increasing weather radio coverage, hazard studies, warning sirens, generators, etc.

M14—Technical Assistance

This category applies to various efforts from multiple state agencies to provide technical assistance, including training, in the identification and mitigation of hazards. The technical assistance can be for local governments or to update state policies and legislation. SEMA also makes a considerable effort to educate the public, local officials, government officials, schools, private associations, and businesses about the value and importance of mitigation programs. SEMA offers mitigation workshops, participates in public forums, provides one-on-one guidance, presents at conferences, provides written materials, develops guidebooks and manuals, publishes success stories, sends out press releases, offers information on the Internet, and provides training materials to local emergency managers, earthquake program partners, floodplain managers, and businesses.

Table 4.1 shows how these 14 action categories meet the objectives and goals identified in **Section 4.1** Hazard Mitigation Goals and Objectives and thus contribute to the overall mitigation strategy. Some of these action categories have already proven successful, as demonstrated in **Section 7.5** Effective Use of Available Mitigation Funding.

Table 4.1. Mitigation Action Categories and Goals Crosswalk

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Objectives	Planning	NFIP/CRS	Risk Comm.	Acquis.	Elevate Relocate Floodproof	Safe Room	EQ/ High Wild	Wildfire	Struct/ Infrastuct.	Response/ Recovery Facilities	State Facilities	Elec. Service Line	5%	Tech Assist.
Goal 1: Improve the Protection of Human Life, Health, and Safety														
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 2: Improve the Protection of Continuity of Government and Essential Services														
Objective 1	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 3: Improve the Protection of Public and Private Property														
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 4: Improve the Protection of Community Tranquility														
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4.2.2. Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions

Mitigation actions in this plan were identified over years of mitigation planning in Missouri by the SRMT and its predecessors (e.g., the State Hazard Mitigation Planning Team (SHMPT) and the Hazard Mitigation Project Coordinating Group). The nature of recent disasters has often dictated the action types and hazards addressed. In the 1990s, widespread flooding emphasized the importance, and benefits of, removing properties from the floodplain. Missouri's drought and tornado events in more recent years have shifted the local interest and focus from flood projects to tornado safe rooms. Identification of specific local mitigation actions typically comes from communities impacted by a disaster, or in more recent years, from proactive communities with local mitigation plans applying for pre-disaster grant funding.

During the 2023 plan update, SEMA and the SRMT assessed existing mitigation actions and developed new actions for consideration based on:

- Review of the updated state risk assessment and information from local risk assessments
- Review of goals and objectives
- Review and assessment of existing state actions, including priorities
- Review of state and local capabilities
- Review of a summary of commonly used actions identified in local plans

Ongoing, revised, and new actions and how they fit with the M categories are summarized in **Section 4.2.4** Review and Progress of Mitigation Actions.

All of the identified mitigation actions have proven to be effective based on past experience with some proving more effective than others. Effectiveness is measured in general terms based on how well the project meets multiple objectives:

- **High**—mitigates impacts to life safety and property
- **Moderate**—mitigates impacts to life safety only or property only
- **Low**- mitigates impacts to property

For example, flood buyout projects not only remove property from the floodplain, but they remove the risk to lives in the floodplain as well and eliminate the need to put first responders' lives in jeopardy during flood events. A tornado safe room may reduce deaths and injuries, but they may not necessarily reduce property damage. Effectiveness of specific projects is measured using FEMA's benefit-cost software modules, which is described in more detail in **Section 7.2.4** Pre-Project Determination of Cost-Effectiveness of Mitigation Measures.

SEMA has chosen to utilize a modified version of the STAPLEE (social, technical, administrative, political, legal, economic, and environmental) criteria for prioritizing mitigation actions. In addition to the seven basic elements, SEMA is also prioritizing mitigation actions based upon impact to historical structures, timeframe for implementation, and mitigation effectiveness. Additionally, mitigation action priorities may be adjusted based upon the current situations and threats. For example:

- Flood mitigation projects (repetitive loss properties high priority)
- Tornadoes and high wind mitigation projects
- Earthquake mitigation projects
- Other, not direct life safety

During the 2023 update, the SRMT measured each of the 25 mitigation actions against the modified STAPLEE criteria and completed a STAPLEE survey (**Figure 4.1** and **Figure 4.12**). The total STAPLEE score for each mitigation action is presented in **Table 4.2** along with prioritization by action category.

Figure 4.1. Modified STAPLEE Survey

Missouri 2023 State Hazard Mitigation Plan

Mitigation Action Prioritization

cympopp@gmail.com (not shared) Switch account

1. Track local community hazard mitigation plans to ensure completion of new plans and updates to existing plans as their 5-year cycle expires.

	Definitely YES (3pts)	Maybe YES (2 pts)	Probably NO (1 pt)	Definitely NO (0 pt)	N/A - I do not feel qualified to rate this question (Null)
Is it SOCIALLY acceptable?	☐	☐	☐	☐	☐
Is it TECHNICALLY feasible and potentially successful?	☐	☐	☐	☐	☐
Does the responsible state agency/department have the ADMINISTRATIVE capacity to execute this action?	☐	☐	☐	☐	☐
Is it POLITICALLY acceptable?	☐	☐	☐	☐	☐
Is there LEGAL authority to implement?	☐	☐	☐	☐	☐
Is it ECONOMICALLY beneficial?	☐	☐	☐	☐	☐
Will the project have either a neutral or positive impact on the ENVIRONMENT?	☐	☐	☐	☐	☐
Will HISTORIC structures be saved or protected?	☐	☐	☐	☐	☐
Could it be IMPLEMENTED quickly?	☐	☐	☐	☐	☐
Will the implemented action likely result in LIVES SAVED?	☐	☐	☐	☐	☐
Will the implemented action likely result in a REDUCTION of DISASTER DAMAGE?	☐	☐	☐	☐	☐

4.2.3. 2023 Updated Mitigation Actions

Table 4.2 details actions that the State is considering to further the implementation of mitigation actions in Missouri. The actions recommended are a result of the 2023 plan review and update and can be accomplished with state effort and/or resources. The table also includes the Action Category M1 - M11, the action title, the lead agency, and supporting agencies. The overall STAPLEE score is listed with the status of the action for this 2023 plan update and potential funding sources for the actions turning into projects. There are no new sources of funding identified in the table below.

Table 4.3 details the actions and how they relate to the different hazards.

Table 4.2. Summary of Mitigation Actions for 2023 Updated Plan

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
1.	M1	Track local community hazard mitigation plans to ensure completion of new plans and updates to existing plans as their 5-year cycle expires.	SEMA Mitigation Section	COG's RPC's	44	High	Ongoing for 2023	This will continue with the 2023 update.	HMA, SEMA Operating Budget
2.	M1	Provide technical assistance, planning assistance, and available funding to RPCs to develop new and updated local community plans, using the latest FEMA guidance materials, the SEMA-developed plan outline, and SEMA-led workshops which emphasized the use of NFIP risk assessment products to identify local mitigation projects. Track workshops provided.	SEMA Mitigation Section	COG's RPC's	47	High	Ongoing for 2023	The revision updates assistance to include "planning" and identifies SEMA developed local mitigation plan outline and associated workshops.	HMA, SEMA Operating Budget
3.	M9	Use RPCs and SEMA staff to encourage and track the inclusion of floodplain management strategies to mitigate risk associated with eligible HHPDs.	SEMA Mitigation Section	COG's RPC's	47	High	New for 2023	New action to support the identification of mitigation actions to reduce vulnerabilities to/from eligible HHPDs.	SEMA Operating Budget
4.	M9	SEMA and MoDNR will conduct quarterly meetings to discuss the High Hazard Potential Dams Program (HHPD). Discussions will include: vulnerabilities and consequences, dam incidents, deficiencies, mitigation actions, challenges, possible solutions to lack of resources to administrating the HHPD grant.	MoDNR	SEMA Mitigation Section	47	High	New for 2023	New action to reduce the vulnerabilities from eligible high hazard potential dams that pose an unacceptable risk to the public.	MoDNR and SEMA Operating Budget
5.	M1	Use RPCs and SEMA staff to encourage and track implementation of actions in local plans. Submit to the "RAT" FEMA Regional Action Tracker.	SEMA Mitigation Section	COG's RPC's	47	High	Revised for 2023	The revision incorporates tracking of actions.	SEMA Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
6.	M1	Continue to refine and enhance vulnerability assessments for natural hazards, for example incorporation of changing future conditions data.	SEMA Mitigation Section	SRMT; Other agencies with pertinent data.	48	High	Ongoing for 2023	With the 2023 Update, vulnerability assessments were completed for all 22 hazards. New data will continue to enhance the vulnerability section as future updates are completed.	HMA, SEMA Operating Budget
7.	M2	Continue to encourage new participation in the NFIP and CRS programs with a special focus on communities within PIR (Paper Inventory Reduction) Counties which have not previously been mapped but are now being updated and encourage existing participants to promote and enforce their floodplain management programs. Track number of new participating communities.	SEMA Floodplain Mgmt Section	FEMA	48	High	Ongoing for 2023	NFIP and CRS will continue to be encouraged and promoted in Missouri with an updated focus on communities within PIR counties.	CAPSSE, HMA, SEMA Operating Budget
8.	M2	Provide a reference and/or support for local communities to implement CRS activities. Track distribution of CRS materials.	SEMA Floodplain Mgmt Section	FEMA	47	High	New for 2023	Keep support tools related to CRS activities up-to-date including local mitigation planning tools, quick guide references, website, etc.	CAPSSE, HMA, SEMA Operating Budget
9.	M3	Publish all statewide vulnerability assessment results, including HAZUS-MH results to RPCs and local governments for mitigation planning purposes and to promote consistency in the updates to local plan risk assessments.	SEMA Mitigation Section	COG's RPC's	47	High	Revised for 2023	The 2023 Plan Update included the development of a website to publish vulnerability assessment result to jurisdictional level.	SEMA Operating Budget
10.	M3	As FEMA/SEMA pioneer into the use of 2D modeling, support and provide technical assistance for FEMA Risk MAP Products to communicate risk and promote mitigation actions. Track workshops providing training and technical assistance for 2D products.	SEMA Floodplain Mgmt Section and Mitigation Section	FEMA	47	High	Revised for 2023	For 2023, incorporate the use of SEMA developed Risk MAP User Guide and associated workshops addressing 2D modeling.	SEMA Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
11.	M3	Support and coordinate the development of real-time technical assistance projects (alternative analyses) as identified during Risk-MAP modeling updates.	SEMA Floodplain Mgmt Section	FEMA	48	High	New for 2023	This action is a collaboration of the Risk MAP effort with mitigation and is a priority for the State.	SEMA Operating Budget
12.	M4	Employ the Loss Avoidance Tool, first developed as part of the 2018 Plan Update, for acquisition and safe room locations following Disaster Declarations to track avoided losses associated with each event.	SEMA Mitigation Section	FEMA	47	High	Ongoing for 2023	Incorporate new disaster information for the loss avoidance tool created with 2018 plan.	HMA, SEMA Operating Budget
13.	M5	Continue to pursue mitigation of flood-prone properties through implementation of the Repetitive Loss Strategy and development/implementation of a Statewide Buyout Strategy. Track reduction in repetitive loss structures.	SEMA Mitigation Section	DED; CDBG	49	High	Ongoing for 2023	Severe Repetitive Loss Properties & Repetitive Loss Properties continue to be a top priority for property buyouts in Missouri with additional focus on the developed strategy. Implement statewide buyout strategy in 2023.	HMA, CDBG, BRIC
14.	M6	Support the construction of tornado safe rooms in local communities' public buildings, public schools, and eligible private non-profit facilities to FEMA standards.	SEMA Mitigation Section	COG's RPC's DESE, DHE, non-profit organizations	49	High	Ongoing for 2023	This is a priority, following flood buyout properties, for grant funds in Missouri & continues to be updated in the 2023 Plan Update.	HMA, CDBG, BRIC
15.	M7	Support the Missouri Statute "Earthquakes - Seismic Building and Construction Ordinances," to require public buildings in the State of Missouri to be designed in accordance with building codes based upon the latest version of the National Earthquake Hazards Reduction Program (NEHRP) provisions for the design of new buildings.	SEMA MoDNR	COG's RPC's	46	Medium	Ongoing for 2023	This is a priority in Missouri & and continues to be supported through SEMA efforts.	SEMA and MoDNR Operating Budget
16.	M7	Support the distribution of Public Education materials regarding Earthquake/High Wind nonstructural mitigation measures. Participate in annual Great ShakeOut earthquake drills.	SEMA MoDNR	COG's RPC's	46	Medium	Ongoing for 2023	These are recognized as significant hazards in Missouri & are supported through SEMA and continue to be updated in the 2023 Plan Update. Action was further described to note distribution of educational materials.	SEMA and MoDNR Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
17.	M9	Maximize the use of PA mitigation funds in Missouri. Track mitigation funds included with all PA projects.	SEMA Public Assistance Section	FEMA Local Communities	45	Medium	Ongoing for 2023	SEMA will seek to maximize the use of PA mitigation funds in Missouri following disaster declarations.	PA mitigation funds
18.	M14	Educate and encourage local jurisdictions to pursue BRIC funding for community mitigation projects. Track outreach materials and workshops covering BRIC funding opportunities.	COG's RPC's	SEMA	46	Medium	New for 2023	As a new grant program, it is good use of SEMA staffing effort to educate eligible jurisdictions.	BRIC
19.	M10	Implement the mitigation actions identified in the comprehensive plan for response and recovery facilities throughout Missouri.	SEMA Response and Recovery Divisions	FEMA Local Communities	45	Medium	Ongoing for 2023	This is recognized as a good use for grant funds in Missouri.	HMA, CDBG, BRIC
20.	M11	Pursue mitigation of state owned/operated facilities which have been identified through the refined risk assessments as at risk.	OA	SEMA, MDC, DHE, MoDOT	45	Medium	Ongoing for 2023	This is recognized as a good use for grant funds in Missouri.	HMA, CDBG, BRIC
21.	M12	Continue to pursue mitigation of municipal and public electric provider's services.	SEMA Mitigation Section	Municipal and public electric providers	38	Low	Ongoing for 2023	This is recognized as a good use for grant funds in Missouri.	HMA, CDBG, BRIC
22.	M13	Support projects that are consistent with the State goals & objectives, but difficult to quantify the benefits using the standard BCA (i.e. warning sirens, permanently installed generators, etc.)	SEMA Mitigation Section	COG's RPC's	42	Low	Ongoing for 2023	This is a consideration for HMGP 5% set aside funds in Missouri.	HMA

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
23.	M14	Support Missouri agencies that own, operate, and/or lease state facilities, continue to improve work to geolocate their facilities as data becomes available to further refine risk assessments using GIS.	OA	SEMA, MDC, DHE, MoDOT	38	Low	Ongoing for 2023	The revision includes all state agencies that own, operate, and/or lease state facilities. This list will continue to be incorporated when this plan is updated every 5 years or as required.	Missouri state funds
24.	M14	Encourage the creation of a State-level Levee Safety Program similar to MoDNR's Dam and Reservoir Safety program.	SEMA MoDNR	COE Silver Jackets	42	Low	Ongoing for 2023	The National Committee on Levee Safety supports the creation of state-level levee safety programs. Mitigation action revised to note Silver Jackets as a supporting agency.	Missouri state funds, COE funds
25.	M13	Continue to coordinate with Dept. of Health and Senior Services for ongoing COVID pandemic/endemic response and recovery needs.	SEMA	DHSS	42	Low	New for 2023	This is a consideration for HMGP 5% set aside funds in Missouri.	SEMA Operating Budget
26.	M1	Assist communities with including Community Wildfire Protection Plans (CWPPPs) as a part of local HMP Updates, as applicable.	SEMA MoDNR	COG's RPC's	45	Medium	New for 2023	CWPPs are critical documents for reducing wildfire risk. Assisting the local communities with incorporation of CWPPs into the HMP will improve effectiveness of wildfire risk reduction efforts.	SEMA Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
27.	M8	Support wildfire fuels reduction grants and projects.	MoDNR	Nature Conservancy	45	Medium	New for 2023	A major risk factor for wildfires is the availability of fuels. Working with communities and/or the Nature Conservancy to reduce hazardous fuels will promote resilience of forested land.	MoDNR Operating Budget
28.	M14	Implementation of development standards that protect people and property from the flood risk associated with levee failure and de-accreditation.	SEMA Floodplain Mgmt Section	COG's RPC's Levee Districts	45	Medium	New for 2023	New action to address risk of people and property behind levees.	SEMA Operating Budget

Note: Supporting Agencies: COE (U.S. Corps of Engineers), COG (Council of Governments), MoDNR (Missouri Department of Natural Resources), FEMA (Federal Emergency Management Agency), MDC (Missouri Department of Conservation), DHE (Department of Higher Education), DHSS (Missouri Department of Health and Senior Services), MoDOT (Missouri Department of Transportation), OA (Missouri's Office of Administration), RPC (Regional Planning Commissions) SEMA (State Emergency Management Agency)

Priority: High denotes action mitigates impacts to life safety and property, moderate denotes action mitigates impacts to life safety only or property only

Funding Sources: CDBG (Community Development Block Grant); HMGP (Hazard Mitigation Grant Program); BRIC (Building Resilient Infrastructure and Communities); FMA (Flood Mitigation Assistance); COE (US Corps of Engineers); CAP-SSE (Community Assistance Program–State Support Services Element)

Table 4.3. How Actions Relate to the Different Hazards

Mitigation Action	Mitigation Category	Flooding	Levee Failure	Dam Failures	Earthquakes	Land Subsidence/Sinkholes	Drought	Extreme Temperatures	Severe Thunderstorms	Severe Winter Weather	Tornadoes	Wildfires	Civil Disorder	Cyber Disruption	Environmental Emergencies	Hazardous Materials Release	Mass Transportation	Nuclear Power Plants	Public Health Emergencies	Special Events	Structural and Urban Fires	Terrorism	Utilities	# of Hazards Addressed
1	M1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
2	M1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
3	M9	X		X																		X		
4	M9	X		X																		X		
5	M1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
6	M1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
7	M2	X	X	X																				3
8	M2	X	X	X																				
9	M3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
10	M3	X	X	X																				3
11	M3	X	X	X											X									4
12	M4	X	X	X							X													4
13	M5	X	X	X					X															4
14	M6								X		X													2
15	M7				X				X		X													3
16	M8											X												1
17	M9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
18	M14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
19	M10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
20	M11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
21	M12				X				X	X	X			X				X				X	X	8
22	M13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22

Mitigation Action	Mitigation Category	Flooding	Levee Failure	Dam Failures	Earthquakes	Land Subsidence/Sinkholes	Drought	Extreme Temperatures	Severe Thunderstorms	Severe Winter Weather	Tornadoes	Wildfires	Civil Disorder	Cyber Disruption	Environmental Emergencies	Hazardous Materials Release	Mass Transportation	Nuclear Power Plants	Public Health Emergencies	Special Events	Structural and Urban Fires	Terrorism	Utilities	# of Hazards Addressed
23	M14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
24	M14			X																				1
25	M13																		X					1
# of Actions Addressing		18	16	19	14	11	11	11	15	12	15	11	11	12	12	11	11	12	12	11	11	14	12	
Probability		100	100	45	72	100	6-11	100	100	100	100	100	<1	<1	<1	100	100	<1	<1	<1	8	<1	100	
Severity		H	M	M	H	L	H	M	M	M	H	L to M	L to H	L to H	L to H	M	M	L to H	L to H	L to H	100	L to H	L	

4.2.4. Review and Progress of Mitigation Actions

During the 2023 update, the status of mitigation actions implemented over the past five years were evaluated to ensure that the State is making progress with its mitigation strategy. Progress is measured based on the following variables:

- The number of projects implemented over time
- The successful disbursement of mitigation grant funds over time
- The disaster losses avoided over time (given a post-disaster event)
- Plans, partnerships, and outreach developed over time

The number of projects that incorporate mitigation while meeting other community objectives, such as a floodplain buyout that becomes a community park and natural area, is another measure of success. These are the types of successful mitigation projects that gain community buy-in and demonstrate tangible benefits. Success stories and methods of reporting them are discussed in **Section 7** Enhanced Plan.

Actions that the State has been involved with between 2002 and 2021 are summarized in **Table 4.4**. The number of actions and amount of Hazard Mitigation Assistance (HMA) funds dispersed through various grant programs indicate that Missouri is continuing to make progress with implementation of its mitigation strategy. The high number of tornado safe room projects (see **Figure 4.2**) reflects the numerous tornado disaster events and the momentum being built by the successful implementation of these projects across the State, especially in more rapidly developing areas where safe rooms are incorporated into the design of new structures (e.g., schools).

Figure 4.2. Construction of Tornado Safe Rooms in Missouri

Note: Photo on left from Holts Summit safe room construction, Photo on right from West Plains safe room construction, Source: SEMA files

Low water crossings are alternatives to bridges in Missouri; however, they are dangerous when drivers attempt to use them during floods. Projects to address these low water crossing dangers entail replacing the crossings with bridges designed to accommodate flood flows. This mitigates impacts on life safety, as lives have been lost when drivers attempt to negotiate low water crossings during floods. More details on mitigation actions, including funding sources used, can be found in **Section 7.5** Effective Use of Available Mitigation Funding and this link to Past Mitigation Projects. Note, mitigation action categories M3 Risk Communication, M10 Response and Recovery Facility Mitigation Projects, and M11

State Owned/Operated Facility Mitigation Projects were added with the 2018 plan update and several generator projects (M10) have been implemented since that time.

Table 4.4. Summary of Mitigation Actions Implemented and Estimated Funding Amounts, 2002–2012; 2013-2017; and 2018-2021

Project Type	Action Category	2002-2012 Number of Projects	2002-2012 Estimated Funding Amount	2013-2017 Number of Projects	2013-2017 Estimated Funding Amount	2018-2021 Number of Projects	2018-2021 Estimated Funding Amount
State and Local Hazard Mitigation Plans[1]	M1	258	$7,885,551	5	$1,096,856	6	$2,691,742
Tornado Safe Rooms	M6	133	$159,925,978	62	$68,575,060	44	$57,832,150
Tornado Safe Rooms - Multipurpose	M6	1	$686,493	---			
Flood Buyouts	M4	67	$47,337,218	18	$8,458,688	30	$9,838,131
State 5% Initiative Projects	M13	12	$1,753,866	10	$598,378	---	
Buried Electric Lines	M12	10	$11,959,530	---		---	
Low Water Crossings	M9	8	$888,246	2	$432,896	---	
Flood Elevations	M5	3	$488,573	---	---	---	
Streambank Stabilizations	M9	2	$92,267	---	---	---	
Culvert	M9	2	$553,625	---	---	---	
Basin	M9	1	$1,333,333	---	---	---	
Bridge Replacements	M9	1	$449,787	---	---	---	
Water Supply Interconnects	M9	1	$66,701	---	---	---	
Generators	M10	---	---	---	---	6	$517,678
Infrastructure Protective Measures	M9	---	---	---	---	4	$1,760,546
Utility Protective Measures	M9	---	---	---	---	2	$968,946
Warning Systems	M3	---	---	---	---	21	$682,193

[1]Note: This table reflects the number of grants, not the total number of plans completed. Multiple plans were completed through some grant projects; therefore the total number of plans completed is much higher.

Details on the above projects, including funding sources and general timeframe are provided in **Table 4.5, Table 4.6,** and **Table 4.7.** These mitigation projects solidify the State's mitigation strategy by demonstrating that the State's goals, objectives, and actions are the basis for these projects.

This documentation indicates that Missouri is effectively using both pre- and post-disaster funding mechanisms and has been successful at securing annual allocations of mitigation funds in the nationally competitive Pre-Disaster Mitigation Grant Program (as of 2020, the BRIC grant program). Since Missouri has an enhanced hazard mitigation plan, they receive 20 percent of post-disaster costs from the Hazard Mitigation Grant Program for mitigation purposes. Several project closeouts are also noted, indicating successful mitigation grant management. **Section 6.2.1** Monitoring Implementation of Mitigation Measures Funded by FEMA provides details on individual project review and closeout procedures.

Table 4.5. HMGP Mitigation Project Summary Table 2002–2021

Year	Tornado Safe Rooms	Flood Buyouts	State 5% Initiative Projects	State and Local Hazard Mitigation Plans	Low Water Crossings	Buried Electric Lines	Culvert	Tornado Safe Rooms - Multipurpose	Water Supply Interconnects	Generators	Infrastructure Protective Measures	Utility Protective	Warning Systems	Total	Total Completed[1]	Total Pending[2]
Action Category	M6	M4	M13	M1	M9	M12	M9	M6	M9	M10	M9	M9	M3			
2002	3	20	5			2								**30**	**30**	**0**
2003		3	1						1	1				**5**	**5**	**0**
2004	1													**1**	**1**	**0**
2006	11	1	1		5	1	1	1						**21**	**21**	**0**
2007	9	10	1			1								**21**	**21**	**0**
2008	3	5		2			1							**11**	**11**	**0**
2009	27	1	1	3		1								**33**	**33**	**0**
2010	2		1											**3**	**3**	**0**
2011	57	2	3	1										**63**	**63**	**0**
2012	41	1	1	1										**44**	**44**	**0**
2013	41	5	2	1										**49**	**49**	**0**
2014	6	1			1									**8**	**8**	**0**
2015	1				1									**2**	**2**	**0**
2016	7		4	2										**13**	**12**	**1**
2017	7		4	1										**12**	**8**	**0**
2018	6	8								1			2	**17**	**17**	**0**
2019	7	3		2						2			1	**15**	**9**	**6**
2020	4	6		2							2	1	1	**16**	**10**	**6**
2021	27	13		2						3	2	1	17	**65**	**20**	**45**
Total	**260**	**79**	**24**	**17**	**7**	**5**	**2**	**1**	**1**	**7**	**4**	**2**	**21**	**429**	**367**	**58**

[1] Number of projects completed are projects in which the final performance is complete as of December 31, 2021.
[2] Number of projects pending are projects that have not completed their scope of work as of December 31, 2021.
Source: State Emergency Management Agency

Table 4.6. FMA, RFC, and SRL Mitigation Project Summary Table 2004–2021

Project Type	Flood Buyouts	Flood Elevations	Total
Action Category	M4	M5	
RFC[1] 2008 - 2012	3	---	3
SRL[1] 2008-2012	1	---	1
FMA 2004-2012	3	2	5
FMA 2013	1	---	1
FMA 2014	1	---	1
FMA 2015	0	---	0
FMA 2016	1	---	1
FMA 2017	8	---	8
FMA 2018	4	---	4
FMA 2019	2	---	2
FMA 2020	2	---	2
FMA 2021	---	---	0
Total	18	2	20
Total Completed[2]	15	2	17
Total Pending[3]	3	0	3

[1] The RFC and SRL programs were eliminated in July 2013 with the Biggert Waters Flood Insurance Reform Act of 2012.
[2] Number of projects completed are projects in which the final performance is complete as of December 31, 2021.
[3] Number of projects pending are projects that have not completed their scope of work as of December 31, 2021.
Source: State Emergency Management Agency

Table 4.7. PDM Mitigation Project Summary Table 2004–2021

Year	Tornado Safe Rooms	Siren/ Generator	Low Water Crossings	Flood Buyouts	Buried Electric Lines	Bank Stabilization	Basin	Bridge Replacement	State and Local Hazard Mitigation Plans[1]	Total	Total Completed[2]	Total Pending[3]
Action Category	M6	M13	M9	M4	M12	M9	M9	M9	M1			
2004	2									**2**	**2**	---
2005	14		2	2	1	2		1	1	**22**	**22**	---
2006	4				1					**5**	**5**	---
2007	12		1							**13**	**13**	---
2008	1	2					1			**4**	**4**	---
2009	1									**1**	**1**	---
2010	1	1								**2**	**2**	---
2011	1									**1**	**1**	---
2012	1									**1**	**1**	---
2013										**0**	---	---
2014										**0**	---	---
2015										**0**	---	---
2016	1									**1**	**1**	---
2017										**0**	---	---
2018	3									**3**	**3**	---
2019	4								1	**5**	---	**5**
Total	**38**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**52**	**51**	**1**

[1]Note: This table reflects the number of grants, not the total number of plans completed. Multiple plans were completed through some grant projects; therefore the total number of plans completed is much higher.
[2] Number of projects completed are projects in which the final performance is complete as of December 31, 2021.
[3]Number of projects pending are projects that have not completed their scope of work as of December 31, 2021.
Source: State Emergency Management Agency

Prior to 2002, Missouri used mitigation funding for buyouts, elevations, and relocations; however, the nature of hazards in Missouri and types of mitigation projects broadened. Flood mitigation remains a priority but changes in threats required SEMA to broaden its perspective in mitigation projects. Since the last State plan update in 2018, the State has successfully completed and proposed flood buyout projects, tornado safe rooms, siren and generator projects, utility and infrastructure projects, and mitigation planning projects, as listed in the tables above.

Progress in the remaining mitigation action categories, those not addressed in **Table 4.4** are summarized below. These action categories are more program- than project-related.

M2—National Flood Insurance Program Floodplain Management and Community Rating System: Participation in the NFIP has increased since the publication of the 2018 plan (see **Table 4.15**). There are an additional 9 communities in the program. As of May 2022, there were 681 NFIP participating jurisdictions, all participating in the regular program. All the participating communities have established local floodplain management ordinances to help them administer the program. Mitigation planning and the Flood Mitigation Assistance grant program have had a positive impact on participation and interest

in the NFIP. The program is expected to continue to grow. Many communities have had their current flood hazards mapped but have not yet joined the program.

Funds from a variety of programs have been used to develop flood maps for areas previously unmapped and to revise or update older existing maps. This initiative will enable more communities in the State to join the NFIP. The Paper Inventory Reduction (PIR) program will assist in getting paper-only floodplain maps updated to a digital format. There are 33 PIR counties in Missouri. All 33 have been funded for countywide updates and all 33 now have digital models available. Nine of the counties are now Effective. Additionally, all 33 have 2D models funded with 12 of the counties issued Preliminary with 2D modeling results. SEMA is coordinating with these counties throughout the Risk MAP process and encouraging participation in the NFIP, as well as the CRS program. Handouts covering the process to join the NFIP have been developed by SEMA to assist non-participating communities. The current status of the Risk MAP program across the state is provided in the flooding hazard discussion in **Section 3.3.1**.

M7—Earthquake/High Wind Structural and Non-Structural Mitigation Projects: No new structural projects were implemented between 2013 and 2021 due in part to the lack of recent damaging earthquake events and the increased interest in tornado safe room projects because of recent tornado disaster events. No new non-structural projects were implemented between 2013 and 2021 due in part to the lack of recent damaging earthquake events and the increased interest in tornado safe room projects because of recent tornado disaster events.

M8 – Wildfire Mitigation Projects: No wildfire mitigation projects were implemented between 2013 and 2021. However, states, federally-recognized tribes and territories affected by fires resulting in an Fire Management Assistance Grant (FMAG) declaration on or after October 5, 2018, are now eligible to apply for FEMA's HMGP Post-Fire assistance.

M14—Technical Assistance: SEMA mitigation staff schedule and conduct various trainings and workshops throughout the year to increase knowledge and understanding of mitigation and floodplain management. Training includes Local Hazard Mitigation Plan Development; Tools of Floodplain Management; Digital Flood Insurance Rate Map (DFIRM) Workshops and DFIRM Plus Risk MAP Workshops; and Certified Floodplain Manager (CFM) Training. Training is further defined in **Section 4.5.1 State** Agency Capability Assessment.

Sections 7.4 Assessment of Mitigation Actions and **7.5** Effective Use of Mitigation Funding provide additional examples of the progress and success of mitigation actions and programs.

4.2.5. Review and Integration with Local Actions

A roll-up and analysis of the mitigation actions contained in local plans was conducted to summarize the types of mitigation actions most commonly implemented, or desired to be implemented. This analysis included a summary of actions and the associated hazards, which give an indication of the priority hazards to be mitigated at the local level.

Methodology

The roll-up was conducted by reviewing and capturing key elements of the mitigation sections of each local plan into a master spreadsheet. Most local plans provided a summary table of their mitigation actions, which included a variety of information, such as action description, category of mitigation action, priority, responsible agency, potential funding sources, hazard addressed, and the action's relationship to the local plan's goals and objectives. Some local plans provided a limited amount of information that made it difficult to summarize their data.

The roll-up of the local mitigation actions focused on evaluating the types of local mitigation actions by determining the following:

- The number of actions for each mitigation category (i.e., prevention, emergency services, property protection, natural resource protection, structural protection, and public information);
- The total number of mitigation actions in each county.

Each mitigation action was reviewed and assigned to the appropriate FEMA-established mitigation categories included in FEMA state and local guidance.

Results

Table 4.8 summarizes the results of the breakdown of local mitigation actions using FEMA's mitigation categories. FEMA's publication Developing the Mitigation Plan emphasizes four categories of mitigation activities that are defined as follows:

- **Local Plans and Regulations:** Administrative or regulatory actions/processes that influence the way land and buildings are developed and built.
- **Structure and Infrastructure Projects**: Actions that involve modifying existing structures and infrastructure to protect them from a hazard or remove them from a hazard area. These projects include:
  - **Property Protection:** Actions include acquisition, elevation, relocation, structural retrofits, storm shutters, and shatter-resistant glass.
  - **Structural Projects:** Actions that involve the construction of manmade structures to reduce the impact of hazard.
- **Natural Systems Protection:** Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems.
- **Public Education and Awareness:** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigation them.

Additionally, many local mitigation plans identified actions which could be categorized as emergency services. These actions protect people and property during and immediately after a disaster or hazard event and include warning systems or sirens, generators, weather radios, and emergency services communications.

Table 4.8. Breakdown of Local Actions by Mitigation Categories

Mitigation Category	Number of Mitigation Actions	Percent	Percent Change since 2018
Local Plans and Regulations	637	29.25%	-8.75%
Emergency Services	468	21.49%	6.29%
Public Education and Awareness	439	20.16%	-6.14%
Property Protection	276	12.67%	2.17%
Structural Projects	256	11.75%	6.35%
Natural Systems Protection	102	4.68%	-0.02%

Based on this summary, a large portion of the actions seemed to be policy and/or regulatory in nature. This means they deal with influencing change on the front-end through community outreach efforts, policy changes, and developing and enforcing new regulations. There was an increase in emergency services, structural, and property protection actions. **Table 4.9** provides a summary the results of the breakdown of county-wide local mitigation actions. Individual jurisdictional mitigation actions are not included.

Table 4.9. Breakdown of Local Actions by Mitigation Categories by County

County	Local Plans & Regulations	Property Protection	Public Education	Emergency Services	Natural Systems	Structural Projects	Total
Adair	6	1	2	7	1	3	20
Andrew	4		4	5	3	2	18
Atchison	3		4	7	1	7	22
Audrain	18		2	4		11	35
Barry			6	1		1	8
Barton	7	1	4	1		3	16
Bates	1		2	5		2	10
Benton	3		3	1		1	8
Bollinger	3			2		4	9
Boone	7	1	4	7		3	22
Buchanan		1	6	6	1	3	17
Butler	5	1	5	7	2	5	25
Caldwell	5		1	4	1	4	15
Callaway	8	2	2	7	1	2	22
Camden	3			2			5
Cape Girardeau	2	2		4	1	1	10
Carroll	6	1	8	11	3	9	38
Carter	10	3	6	3		3	25

County	Local Plans & Regulations	Property Protection	Public Education	Emergency Services	Natural Systems	Structural Projects	Total
Cass	2	3	4	2		2	13
Cedar	1	1		4			6
Chariton	1	1		3		2	7
Christian	8	3	8	2	2	1	24
Clark	1	1		4		1	7
Clay	5	3	5	7		2	22
Clinton	9	1	4	3			17
Cole	3	1		1			5
Cooper	3	2		3		4	12
Crawford	13	4	8	1	1		27
Dade	5	4	3	6	2	3	23
Dallas	5	4	4	3	2		18
Daviess	3		8	13	1	5	30
DeKalb	6		13	9	1	3	32
Dent	9	4	9	6	2	5	35
Douglas	2	3		2		1	8
Dunklin	10	1	4	2		3	20
Franklin	10	10	9	9	6	5	49
Gasconade	6	2	5	1		1	15
Gentry	13	5	5	3	1	1	28
Greene	1	1	3	6		1	12
Grundy	3	2	7	11	3	3	29
Harrison	6	1	7	9	2	4	29
Henry			2	2		1	5
Hickory	2			2		1	5
Holt	10	1	3	5	1	2	22
Howard	13	5	10	11	2	3	44
Howell	2	8	1	6		2	19
Iron	1	1		1		1	4
Jackson	18	9	24	5	4	5	65
Jasper	20	2	7	7		1	37
Jefferson	11	11	6	10	6	5	49
Johnson	3	3	3	3	1		13
Knox	2	1		3		2	8

County	Local Plans & Regulations	Property Protection	Public Education	Emergency Services	Natural Systems	Structural Projects	Total
Laclede	1	1					2
Lafayette	3	1	3			1	8
Lawrence	5		8	5	1	3	22
Lewis	3		5	3			11
Lincoln	4	1				2	7
Linn	6	3	4	10	1	2	26
Livingston	10		4	8	1	2	25
Macon	1	3	1	6		3	14
Madison	4	2	1	4	3	1	15
Maries	14	4	9	1		1	29
Marion	2	1	1	3	1	3	11
McDonald	2	3	3	2		3	13
Mercer	3	2	6	3	1	2	17
Miller	1	7	1	2		6	17
Mississippi	5	2				1	8
Moniteau	12	2	6	9	1	1	31
Monroe	3	2		4	1	1	11
Montgomery	4						4
Morgan	1	5					6
New Madrid	11	3	3	4	1	2	24
Newton	20	2	7	7		1	37
Nodaway	8	2	8	9	2	2	31
Oregon	2	4	1	10		3	20
Osage	11	4	8	1	1	2	27
Ozark		2					2
Pemiscot	5	2	3	1			11
Perry	1	1		2		1	5
Pettis	3	2	3	2	1	1	12
Phelps	10	4	7	5		1	27
Pike	1	1		1			3
Platte	12	9	9	4	4	3	41
Polk	5	4	3	4	1	2	19
Pulaski	13	4	5	5		2	29
Putnam	1		1	2	2		6

County	Local Plans & Regulations	Property Protection	Public Education	Emergency Services	Natural Systems	Structural Projects	Total
Ralls	1			3		2	6
Randolph	1	2		3		1	7
Ray	2	3	9	1		2	17
Reynolds	3	2	2	7	1	1	16
Ripley	7	4	3		1		15
Saline	7	1	2	1		1	12
Schuyler	2	1		3		3	9
Scotland	2	1		3		3	9
Scott	6	3	2				11
Shannon	1	2		3		4	10
Shelby		2	2	2		1	7
St. Charles	10	10	9	9	6	5	49
St. Clair	2		1				3
St. Francois	1			2		2	5
St. Louis	10	10	9	9	6	5	49
St. Louis City	10	10	9	9	6	5	49
Ste. Genevieve	2	3		3	1	2	11
Stoddard	2		2	3		1	8
Stone	7	1	9	3	1	1	22
Sullivan		1	1	3	1		6
Taney	10	3	8	1		1	23
Texas		1		2		1	4
Vernon	2		1	1		1	5
Warren	2	1		1			4
Washington	17	5	7	3	1	1	34
Wayne	6	2	6	4		2	20
Webster	28	11	23	16	5	16	99
Worth	6	1				2	9
Wright	3	2	1	7		5	18
AMEC MO Electric COOP	2		2			2	6
Grand Total	**637**	**276**	**439**	**468**	**102**	**256**	**2178**

4.2.6. Challenges in Implementation

In general, the State has been very successful in implementing mitigation projects. SEMA averages approximately $20 million dollars in federal grant funding each year. There has been an average of 28 disaster-related HMGP projects each year over the past four years (2018-2021), an increase from an average of 23 projects for 2013-2017. Non-disaster related funds continue to be utilized with FMA funding for residential acquisitions in 2019 and 2021.

Funding, or lack thereof, has been a major challenge in implementing mitigation projects in Missouri. Missouri is poised to take advantage of new grant programs, such as the Building Resilient Communities and Infrastructure (BRIC) and Flood Mitigation Assistance (FMA) programs, which provide annual allocations to fund both plans and projects. Missouri experiences Presidential disasters frequently and as a result obtains significant Hazard Mitigation Grant Program funds. The fact that Missouri regularly experiences disasters presents its own special challenge, as SEMA mitigation staff are often involved in response and recovery operations in addition to mitigation program administration. Solutions to this challenge include developing innovative solutions for surge capacity backfill of SEMA mitigation staff. Currently this is accomplished through special contracts.

Implementation and enforcement of hazard-resistant building codes statewide has been a challenge, including enforcement of Missouri State Statute (§§ 319.200-319.207) requiring adoption of seismic construction and renovation ordinances. In Missouri, building codes are adopted and governed at the local jurisdiction level, while the state adopts codes for state owned buildings. Knowing seismic-resistant building codes establish a level of protection to minimize the likelihood of building collapse during earthquakes, enforcement of seismic construction and renovation ordinances at the local level would provide higher protection and damage reduction for local critical facilities, schools, and storage buildings containing hazardous materials. Support for the state statute continues to be included as mitigation action item.

Additional information on project implementation is demonstrated in **Section 7.2** Project Implementation Capability.

4.2.7. Mitigation Success

Mitigation successes are discussed in detail in **Section 7.5** Effective Use of Available Mitigation Funding.

4.3. Repetitive Flood Loss Strategy

Requirement §201.4(c)(3)(v): A State may request the reduced cost share authorized under §79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan… that also identified specific actions the State has taken to reduce the number of repetitive loss properties (which must include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties.

In addition, the plan must describe the strategy the State has to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local mitigation plans.

Note: The Biggert-Waters Flood Insurance Reform Act of 2012 consolidated the SRL grant program into the FMA grant program

4.3.1. Background on the NFIP and Repetitive Loss

Flooding is the most common natural hazard in the United States. More than 22,000 communities experience floods and this hazard accounts for approximately 75 percent of all Presidential Disaster Declarations. Over 8 million residential and commercial structures in the US are currently built in areas subject to flooding. The costs of these disasters are spread among local, state and federal governments and the individual victims themselves.

The National Flood Insurance Program (NFIP) is continually faced with the challenge of balancing the financial soundness of the program with competing expectation of keeping flood insurance premiums affordable. According to the Congressional Research Services' (CRS) October 3, 2022, Report on FEMA's National Flood Insurance Program, there are nearly 5 million flood insurance policies providing almost $1.3 trillion in coverage.

One of the largest obstacles to achieving financial soundness of the NFIP is the repetitive loss property. Repetitive Loss (RL) properties are those properties with two or more claims of $1,000 paid against the NFIP; and a subset of that, is the severe repetitive loss property. Severe repetitive loss (SRL) properties are those that have incurred four or more claim payments exceeding $5,000 each, with a cumulative amount of such payments over $20,000; or at least two claims with a cumulative total exceeding the value of the property.

According to FEMA, all repetitive loss (RL) and severe repetitive loss (SRL) properties amount to approximately $17 billion in claims over the history of the program, or approximately 30% of total claims paid. Reducing the number of RL and SRL properties, through mitigation or relocation, could reduce claims and improve the NFIP's financial position.

Another obstacle to achieving financial soundness of the NFIP is that FEMA has not historically been allowed to eliminate coverage for any policy holder including high-risk properties. FEMA has only been authorized by Congress to make incremental adjustments to increase premium rates and reduce overall coverage. For example, in April 2019, FEMA began charging a 5% premium on all severe repetitive loss properties. Since repetitive flood claims must be paid, FEMA has had no choice but to spread these costs among all policy holders.

Because of past significant flood events and more recent ones (Hurricane Katrina in 2005, Superstorm Sandy in 2012, and the 2017 hurricane season), the NFIP Fund is in debt to the US Treasury in the amount

of $30.4 billion. It may not be realistic to recover this debt through premium increases for Pre-FIRM properties and by eliminating grandfathering of rates. Congress may need to take further action to protect the solvency of the NFIP.

On October 26, 2017, Congress cancelled $16 billion of NFIP debt to make it possible for the program to pay claims for Hurricanes Harvey, Irma, and Maria. FEMA borrowed another $6.1 billion on November 9, 2017, to fund estimated 2017 losses, including those incurred by Hurricanes Harvey, Irma, and Maria, bringing the debt back up to $20.525 billion. The NFIP has not needed to borrow from the Treasury since 2017. As of October 2022, the NFIP has $9.9 billion of remaining borrowing authority, as well as possible reinsurance payments of up to $2.34 billion.

Increased costs associated with flood events is evidenced in **Table 4.10** which lists the top 20 floods in terms of NFIP payouts. To be included on this list, the minimum threshold is at least 1,500 flood insurance claims.

Table 4.10. Top 10 Significant Flood Events Covered by the National Flood Insurance Program (1978 to December 31, 2021 as of March 9, 2022; $ nominal)

Rank	Event	Date	Number of Paid Losses	Amount Paid ($ Millions)	Average Paid Loss
1	Hurricane Katrina	Aug. 2005	168,256	$16,092	$95,640
2	Hurricane Harvey	Sep. 2017	78,254	$9,171	$117,192
3	Superstorm Sandy	Oct. 2012	132,897	$8,619	$64,852
4	Hurricane Ike	Sep. 2008	47,247	$2,670	$56,517
5	Louisiana severe storms and flooding	Aug.2016	27,737	$2,536	$91,432
6	Hurricane Ivan	Sep. 2004	31,981	$1,688	$52,791
7	Hurricane Ida	Sep. 2021	28,544	$1,589	$55,658
8	Hurricane Jeanne	Sep. 2004	31,486	$1,513	$48,062
9	Hurricane Irene	Aug. 2011	44,178	$1,321	$29,894
10	Hurricane Irma	Sep. 2017	23,119	$1,153	$49,884

Source: U.S. Department of Homeland Security, Federal Emergency Management Agency.

While most Special Flood Hazard Area (SFHA) properties are charged the true actuarial rate based on the flood risk to that building, there is a subset of properties called Pre-FIRM (constructed or substantially improved prior to July 31st, 1974, or before the community adopted its first Flood Insurance Rate Map (FIRM), whichever is later) which were allowed by statute to have lower premiums than predicted to cover potential future claims. Because of federal legislative changes to the NFIP through Section 100205 of the Biggert-Waters Flood Insurance Reform Act of 2012 (BW-12) and Sections 3 and 5 of the Homeowner Flood Insurance Affordability Act of 2014 (HFIAA), the Pre-FIRM subsidy will be progressively phased out (different pace of phase out based on the property type). Therefore, premiums for Pre-FIRM properties will reach sound actuarial rates which represents the true flood risk for that location.

As previously noted, the NFIP has nearly 5 million policies in force covering almost $1.3 trillion in property in around 22,000 participating communities. These 5 million policies generate about $4 billion in annual premium revenue. Since 1978 when the NFIP started keeping more accurate records, payouts of $1 billion to policy holders have happened nine times. The first of which was in 1995. The other years where payouts exceeded $1 billion were in 2001, 2004, 2005, 2008, 2011, 2012, 2015 and 2016. Five of those times were in a 10-year period from 2001 to 2011.

Before the inception of the NFIP, flood hazards in the United States, whether from hurricanes and coastal storm surge or inland flooding on rivers, streams, and lakes, was largely deemed uninsurable from the private insurance industry. Hurricane Betsy in September of 1965, a Category 3 storm, was the first natural disaster in the U.S. to generate over a billion dollars in damage without an insurance program to help property owners recover and rebuild. In response, largely on a basis of the “general welfare” and “interstate commerce” clauses of the U.S. Constitution, Congress created the NFIP in 1968. The NFIP would regulate the nation’s floodplains (Special Flood Hazard Areas – SFHA) with land use controls and building requirements that communities in the SFHA must adopt and enforce in order for property owners to be eligible for insurance.

Properties that experience repetitive flood losses—RL properties and Severe Repetitive Loss (SRL) properties—account for a disproportionate share of all flood insurance claims filed under the NFIP. About 1 in 10 homes that suffer repetitive flood damages have cumulative flood claims that exceed the value of the structure. It is estimated by FEMA that almost 90% of RL properties were built prior to December 31, 1974 or before the adoption of a FIRM and are subject to premium discounts.

4.3.2. Definition of Repetitive Loss and Severe Repetitive Loss

Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties create a drain on the National Flood Insurance Fund (NFIF). These properties increase the NFIP’s annual losses and may cause increases for additional borrowing from the Treasury Department. More importantly, they take away resources needed to prepare for catastrophic events. **Table 4.11** presents repetitive flood losses for the United States. Definition of RL/SRL see **page 4.37**.

Table 4.11. Total Repetitive Flood Loss Properties in the NFIP: 1978-2022 (As of April 5, 2022: $ nominal)

Total payments	$28,771,146,004
Average payment	$36,73.1
Number of Losses	783,931
Number of Properties	1,048,646

Source: U.S. Department of Homeland Security, Federal Emergency Management Agency.

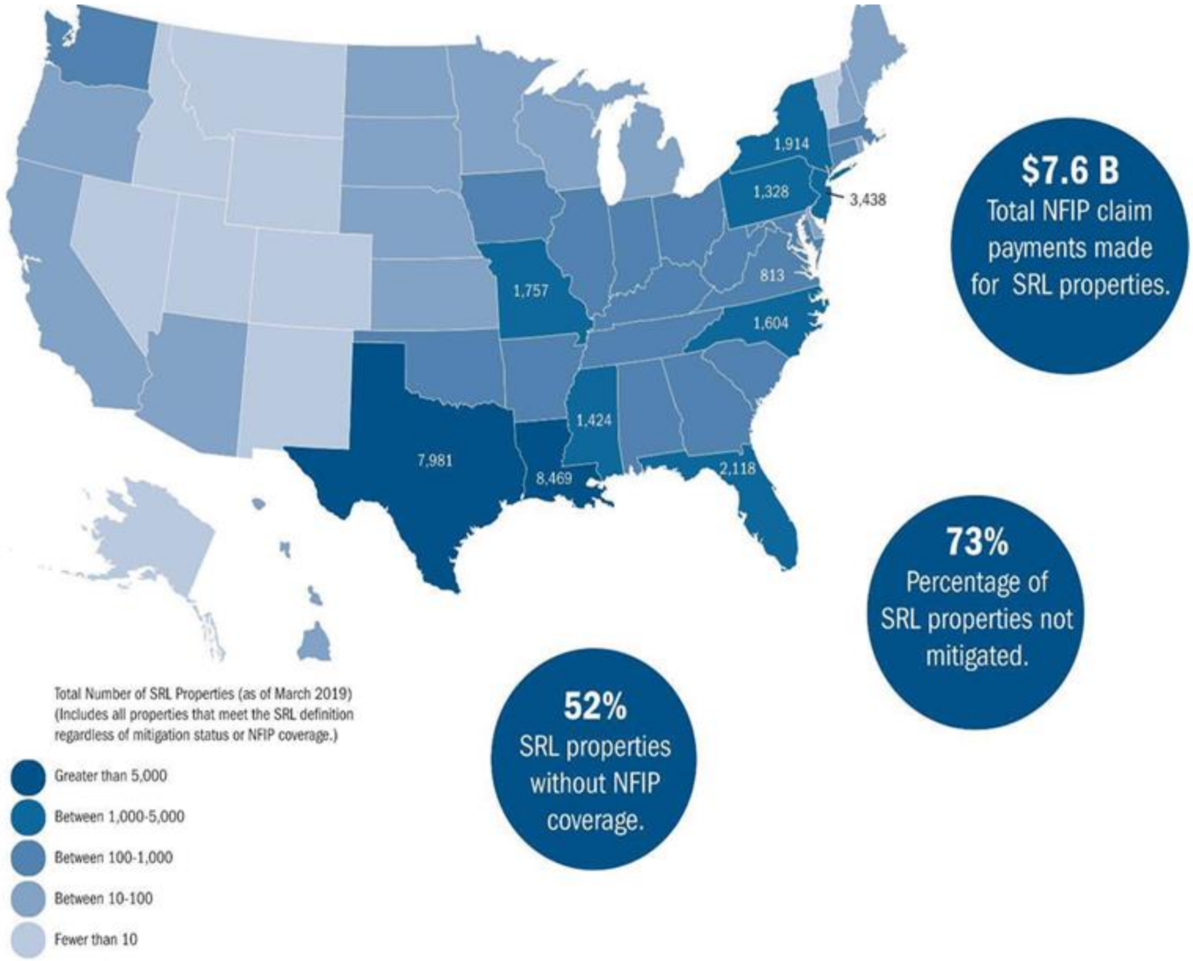
Table 4.12 shows the historical repetitive flood problem within the state of Missouri. Since 1978 when FEMA began keeping better records, Missouri accounts for 2% of total claims payments against the NFIP. The state of Missouri as of April 5, 2022, has 0.6% of the total number of repetitive loss properties in the US.

Table 4.12. Total Repetitive Flood Loss Properties in the State of Missouri: 1978-2022 (As of April 5, 2022: $ nominal)

Total payments	$561,121,845
Average payment	$25,415
Number of Losses	22,932
Number of Properties	6,161

Source: U.S. Department of Homeland Security, Federal Emergency Management Agency.

Figure 4.3. Distribution of SRL Properties Across the US, as of March 31, 2019



Source: U.S. Department of Homeland Security, Office of Inspector General

One issue with trying to reduce the number of RL properties is enforcement of local flood damage prevention ordinances and the substantial damage requirement. Historically, there has been a reluctance to enforce and inconsistencies in enforcement of the substantial damage requirement (i.e., building damaged 50% or more of market value). Some communities have solved this problem by incorporating a Cumulative Substantial Damage requirement (improvements or damages counted cumulatively) in their ordinance.

4.3.3. Federal Requirements for a Repetitive Loss Strategy

To be eligible to receive an increased Federal cost share of up to 90 percent for project grants related to reducing losses to severe repetitive loss properties, mitigation plans must specifically address such projects. States may address the repetitive loss strategy through an amendment to their existing FEMA-approved State Mitigation Plans, or they may accomplish this as part of a cyclical update.

To be eligible for an increased Federal cost share of up to 90 percent under the SRL program, the FEMA-approved State or Tribal Standard Mitigation Plan must also meet all of the requirements described on the following pages:

Repetitive Loss: Any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. Two of the claims paid must be more than 10 days apart but, within 10 years of each other. A repetitive loss property may or may not be currently insured by the NFIP.

Severe Repetitive Loss: As defined by the Flood Insurance Reform Act of 2004, SRLs are 1-4 family residences that have had four or more claims of more than $5,000 or at least two claims that cumulatively exceed the building's value. The Act creates new funding mechanisms to help mitigate flood damage for these properties.

Per the National Flood Insurance Manual, approximately 11,900 policies out of the total 160,000 RL were classified as SRL. As these policies come up for renewal, they will be (if not already) transferred to the NFIP Servicing Agent's Special Direct Facility (SDF) away from being handled by any Write-Your-Own (WYO) company.

A Congressional Research Service report in October 2020 indicates RL and SRL properties make up approximately 30% of claims paid. FEMA, along with other agencies, placed a greater emphasis on mitigation after the 1993 Midwest floods where hundreds of millions were spent to remove frequently flooded structures from the floodplain.

From a national perspective, over $17 billion in total payments have been paid to RL properties. FEMA has implemented many different methods over the years to deal with the RL property problem. During the last reform to the Flood Insurance Program in 2012, the Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL) grant programs were eliminated and combined in the Flood Mitigation Assistance Program (FMA).

a) **Repetitive Loss Strategy** - *44 CFR 201.4(c)(3)(v): A State may request the reduced cost share authorized under Sec. 79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan meeting the requirements of this section that also identifies specific actions the State has taken to reduce the number of repetitive loss properties (which must include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties. This requirement supplements the risk assessment and mitigation strategy portions of the plan required under 201.4(c)(2) and (3) by specifically identifying goals, capabilities, and actions that will reduce the number of repetitive loss properties, including severe repetitive loss properties.*

The mitigation strategy is based on the State's Risk Assessment as required under 201.4(c)(3)(ii). Therefore, the State must address repetitive loss structures in its risk assessment, where applicable. For example, in its overview of Estimating Potential Losses by Jurisdiction under 201.4(c) (2)(iii), the State may analyze potential losses to identified repetitive loss properties based on estimates provided in local risk assessments. The Plan should refer generally to geographic areas where concentrations of repetitive loss properties are located for the purpose of identifying and prioritizing areas for mitigation projects, or the plan may list the number of repetitive loss properties with aggregate repetitive loss data.

The State Hazard Mitigation Goals under 201.4(c)(3)(i) must support the selection of activities to mitigate and reduce potential losses to structures susceptible to flood damage, including repetitive loss properties. In addition, the State and Local Capability Assessments required under 201.4(c)(3)(ii) must include an evaluation of policies, programs, and capabilities that allow the mitigation of repetitive losses from flood damage.

The State must describe specific actions that it has implemented to mitigate repetitive loss properties, and specifically actions taken to reduce the number of severe repetitive loss properties as a subset of all repetitive loss properties in the State. If the State cannot show that any action has ever been taken to reduce the number of such properties, this criterion cannot be met.

Based on the findings of the risk assessment, the State must identify actions in the statewide mitigation strategy that specifically address repetitive loss properties, including those that are severe repetitive loss properties. This supplements the mitigation actions requirement under 201.4(c)(3)(iii). Mitigation actions should be tied to goals and objectives and provide the means to achieve them. Actions should have been identified in the planning process, and local plans should be consistent with state-wide actions. As part of the mitigation strategy, the plan must also describe the current funding sources as well as potential sources that will be pursued to fund proposed mitigation actions for repetitive loss properties. This supplements the identification of funding requirement under 201.4(c)(3)(iv)

b) **Coordination with Repetitive Loss Jurisdictions** - *44 CFR 201.4(c)(3)(v): The plan must describe the strategy the State has to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local mitigation plans.*

The State is required to identify strategies that encourage local communities to mitigate severe repetitive loss properties, including the development of local mitigation plans. This supplement the Coordination of Local Mitigation Planning portion of the plan under 201.4(c)(4). At a minimum, the State must include severe repetitive loss in the description of its process for providing funding and technical assistance to prepare mitigation plans 201.4(c)(4)(i)), and in its criteria for prioritizing communities that have such properties for planning and project grant assistance 201.4(c)(4)(iii)). Other strategies for encouraging local communities to mitigate severe repetitive loss properties should be demonstrated through specific actions identified in the Mitigation Strategy.

4.3.4. National Flood Insurance Reform Act of 2004

The Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004 was signed into law by President George W. Bush on June 30 of the same year. The Act (Public Law 108-264) revised the existing Flood Mitigation Assistance (FMA) Program by creating a Pilot Program at $40 million per year to mitigate severe repetitive loss properties. It reduced the non-federal match from 25% to 10% with an approved mitigation plan that specifies the state's strategy to reduce the number of severe repetitive loss properties. Missouri has developed this Repetitive Flood Loss Strategy in part to receive this share reduction.

The Federal Insurance Administration database shows claims paid that reflect either Repetitive Loss (RL) properties or Severe Repetitive Loss (SRL) properties. Residential SRL properties receive priority for mitigation under the NFIP Reform Act of 2004 (Public Law 108-264). The primary goal of the Program is to reduce excessive flood claim payments and reliance on the National Flood Insurance Fund for flood relief when mitigation is an option.

For the FMA program, FEMA may contribute funding to eligible projects as follows.

- Up to 100% federal cost share for SRL properties or the expected savings to the NFIP for acquisition or relocation activities. The Greatest Savings (GSF) was discontinued because of the changes enacted by the Waters Flood Insurance Reform Act of 2012. GSF used to be offered to the property owner if the project is not cost-effective using pre-event or current market value.
- Up to 90% federal cost share for RL properties.
- Up to 75% federal cost share for NFIP-insured properties. Cost share requirements are summarized in Table 4.13 below. Therefore, with the inclusion of the RL strategy in this plan, cost shares of up to 90%/10% and 100%/0% are available for eligible projects as noted below.

Table 4.13. FEMA HMA Cost Share Requirements

HMA Program	Percent of Federal/ Non-Federal Cost Share
Hazard Mitigation Grant Program	75/25
Hazard Mitigation Grant Program Post Fire	75/25
Building Resilient Infrastructure and Communities	75/25
Building Resilient Infrastructure and Communities - Economically Disadvantaged Rural Communities	up to 90/10
Flood Mitigation Assistance (Localized Flood Risk Reduction, Project Scoping, individual mitigation of insured properties, and planning grants)	75/25
Flood Mitigation Assistance Socially Vulnerable Communities with a Center's for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) of 0.5 or greater	up to 90/10
Flood Mitigation Assistance – Repetitive Loss Property	90/10
Flood Mitigation Assistance – Severe Repetitive Loss Property	100/0
Safeguarding Tomorrow RLF	90/10

Source: https://www.fema.gov/fact-sheet/summary-fema-hazard-mitigation-assistance-hma-programs

4.3.5. State Mitigation Goals that Support Reducing Repetitively Flooded Properties

This Repetitive Flood Loss Strategy is supported by the State Mitigation Goals (restated below) to reduce repetitively flooded properties. Goal 1 and Goal 3 both support the development and funding of sensible mitigation projects to eliminate repetitive flood losses. Goal 4 supports the Community Buyout Program by creating deed restricted open space areas. Properties that have no buildings means emergency services will not have to respond to either evacuate or rescue people. Additionally, since the property must be kept as open space for perpetuity, damage to the building has been eliminated and no new buildings can be constructed on site.

Goal 1: Implement mitigation actions that improve the protection of human life, health, and safety from the adverse effects of disasters.

Goal 2: Implement mitigation actions that improve the continuity of government and essential services from the adverse effects of disasters.

Goal 3: Implement mitigation actions that improve the protection of public and private property from the adverse effects of disasters.

Goal 4: Implement mitigation actions that improve the protection of community tranquility from the adverse effects of disasters.

4.3.6. State Mitigation Outreach Objectives to Reduce the Number of Repetitively Flooded Properties

This Repetitive Flood Loss Strategy is based on the State Risk Assessment and the State addressing repetitively flooded structures in its risk assessment. The mitigation of RL properties should occur through the coordination of local plans and through a mitigation strategy in this plan. SEMA provides guidance and outreach to all state communities through digital methods (via emails to mitigation contacts and through online website information) and workshops at the inception of each pre-disaster and post-disaster grant period. SEMA will inform local jurisdictions of the number of repetitive loss properties and indicate the prioritization of RL properties in its grant announcement to ensure communities with RL and SRL properties are fully aware that grant monies are available for acquisition, relocation and/or elevation projects. Follow-up with communities who are interested in elevation or buyout projects will be considered a high priority for staff members at SEMA. For FMA project funding opportunities, the State of Missouri considers RL and SRL properties to be the highest priority factor in making grant awards to local communities.

Therefore, the State of Missouri Mitigation Strategy consists of the following objectives:

- Local jurisdictions with RL and SRL properties will be encouraged to take actions to reduce the number of these properties by identifying those properties and working with them to explain the benefits of FEMA's HMA Grant Programs.
- Identify and describe RL and SRL properties for each community so that funding and technical assistance is available to prepare local mitigation plans that addresses the mitigation of these properties.
- Prioritize project grants for communities that have RL and SRL properties and who have targeted them for mitigation projects such as elevation or acquisition.

4.3.7. Status of Repetitive Loss in Missouri

As of April 5th, 2022, the State of Missouri had 895 properties designated as Severe Repetitive Loss with total payments to property owners (building and contents) of more than $216 million. These 895 SRL properties had 5,993 losses or an average of 6.7 losses for each SRL property. These 895 SRL properties is an increase of approximately 700 properties since the previous 2018 State Plan; however, the average number of losses has decreased from 7.7 to 6.7 since the previous plan. Note, the data source has changed from BureauNet to PIVOT since the previous plan and could be the source of data discrepancies and/or the unmitigated repetitive loss properties have become severe repetitive loss properties.

There were 2,818 properties designated as Repetitive Loss Properties as of April 5th, 2022. Paid claims on these buildings totaled more than $201 million. There were 7,714 losses for these 2,818 properties which means each property had an average of 2.7 losses per property. This average of 2.7 losses per property is a decrease from the previous 2018 State Plan with an average of 3.7.

See **Appendix A** for the individual county data including number of repetitive and severe repetitive loss properties, number of paid NFIP claims, total paid losses and average payment.

Severe Repetitive Loss Summary

- St. Charles County has the greatest number of SRL properties with 190, followed by Jefferson County with 132 and St. Louis County with 131.
- The median average SRL payment across all communities in the State is $19,868 and the mean is $30,788. This indicates that there are several outlier communities with average SRL payments significantly higher than the median average payment. For example, the average payment for select counties include:
  - $180,144 in City of Marquand in Madison County
  - $133,489 in Holt County, and
  - $101,654 in Ozark County.
  - High average payments may be an indication of high real estate prices and/or higher levels of coverage.
- The counties with the highest average number of losses per SRL property are Scott County (15); St. Louis City (13); Boone and St. Francois Counties (12.5); and Pike County (11).

Repetitive Loss Summary

- Those counties with the greatest number of RL properties are St. Louis County (538); St. Charles County (337); and Jefferson County with (238).
- The median average RL payment across all communities in the State is $21,856 and the mean is $25,167. As with the SRL average payments, this indicates that there are several outlier communities with average RL payments significantly higher than the median average payment. For example, the average payment in select counties include:
  - $125,852 in the City of St. Joseph in Buchanan County
  - $91,763 in Crawford County; and
  - $45,570 in the City of Grandview in Jackson County.
- The counties with the highest average number of losses per RL property are Pike, Audrain, Lincoln, Howard, St. Charles, Lewis, and Ste. Genevieve Counties with over 3 losses per property.

Figure 4.4. Severe Repetitive Loss Properties by County

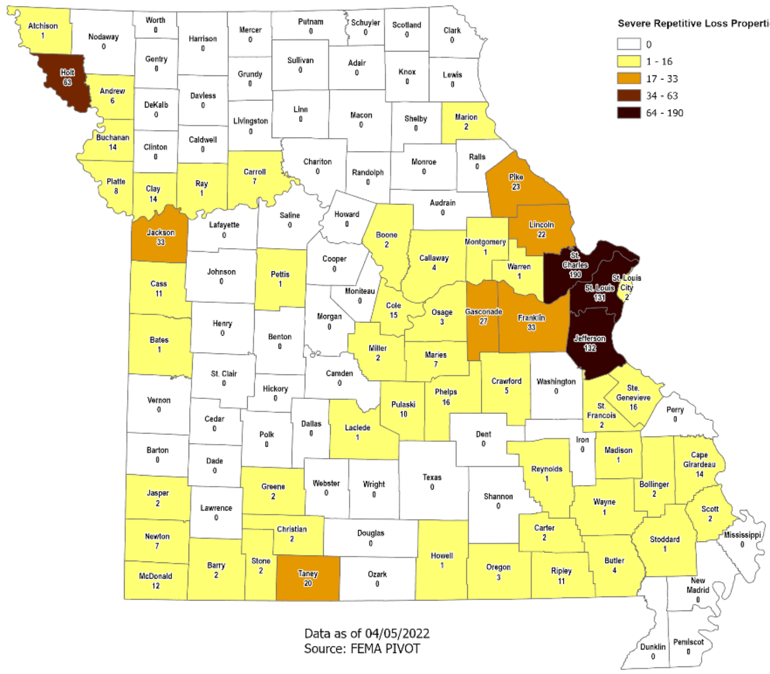
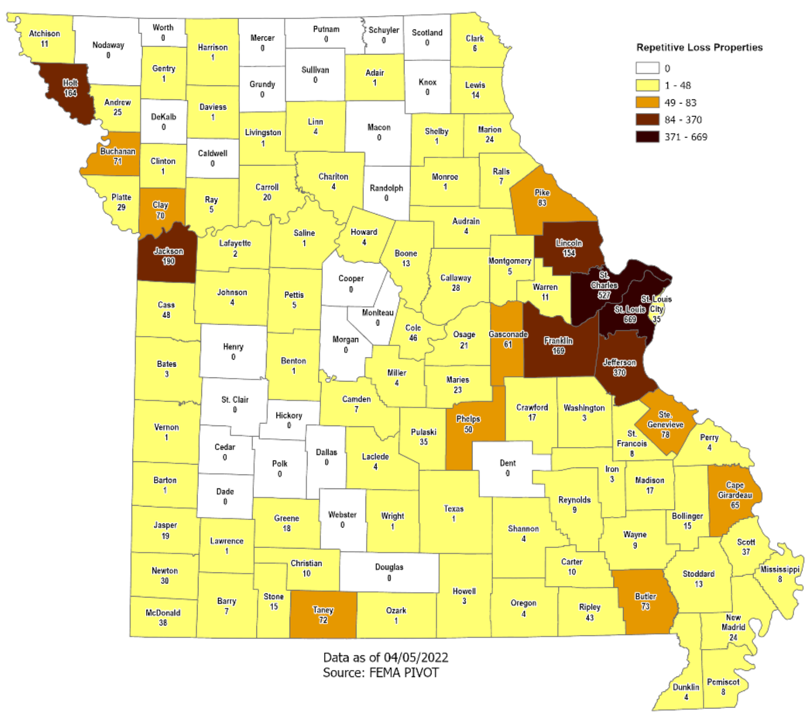


Figure 4.5. Repetitive Loss Properties by County



4.3.8. State Hazard Mitigation Capabilities, Programs, and Policies that Support Reducing Repetitive Flood Loss Properties

Section 4.5.1, State Agency Capability Assessment, discusses the State's Community Buyout Program that has been successful since the Great Flood of 1993 and continues to be a priority for mitigation funding in Missouri. It also states that RL and SRL properties are a priority under this program.

The State Hazard Mitigation Officer (SHMO) has direct access to PIVOT spreadsheets listing the RL properties and the SRL properties by address in Missouri. The SHMO uses these spreadsheets to track the mitigated and non-mitigated properties and thus supports the Repetitive Flood Loss Strategy. These PIVOT spreadsheets are further used by the SEMA Lead Mitigation Planner dedicated to assisting the local planners. The SEMA Lead Mitigation Planner sends the list of RL & SRL properties with a privacy act disclaimer to the planners in local communities. The SEMA Lead Mitigation Planner also double checks their information in the county-level draft hazard mitigation plans against the PIVOT spreadsheets to ensure accuracy.

In addition, the SHMO sends out a Notice of Funding Opportunity letter after presidential disaster declarations notifying counties of the availability of opportunities to apply for Hazard Mitigation Grant Program (HMGP) funding. Where applicable, this letter alerts the local elected officials that there are RL & SRL properties within their community and describes these properties as a priority for the volunteer buyout program in Missouri. Additional details concerning the SHMO duties and the mitigation planners' duties are discussed in **Section 6.2.4** Agency Roles and Responsibilities.

Local community hazard mitigation plans discuss and address their repetitive flood loss properties at differing levels. SEMA encourages local community mitigation plans to turn their discussion of repetitive loss properties into more local mitigation actions to further reduce the number of repetitive loss properties across the State.

4.3.9. State Mitigation Actions that Support Reducing Repetitive Flood Loss Properties

Section 4.2 Mitigation Actions, Category M4—Voluntary Property Acquisitions, discusses that one of SEMA's top priorities is repetitive flood loss and severe repetitive loss properties. This is supported by the amount of obligated funds for flood buyout projects since 2002. The state has obligated more than $23.4 million in that timeframe for property buyouts. Since 2017, the last State Hazard Mitigation Plan, the state has obligated $9.8 million for the buyout of 30 buyout projects.

To further demonstrate Missouri's action to reduce repetitively flooded properties, the tables below indicate the number of mitigated Severe Repetitive Loss (SRL) Properties and the number mitigated of Repetitive Loss (RL) Properties.

Over the history of the SRL program, the State of Missouri has mitigated 509 SRL properties with total paid NFIP claims of over $64 million in 29 counties. St. Charles and St. Louis Counties have the most mitigated severe repetitive loss properties at 220 and 151, respectively.

Likewise, the State of Missouri has mitigated 1,938 RL properties over the history of the RL program with total paid NFIP claims of more than $77 million in 53 counties and 1 independent city. In Jefferson, Lincoln, St. Charles and St. Louis Counties, more than 200 RL properties have been mitigated in each.

See **Appendix A** for the individual county data including number of mitigated repetitive and severe repetitive loss properties, number of paid NFIP claims, total paid losses and average payment.

Figure 4.6. Mitigated Severe Repetitive Loss Properties by County

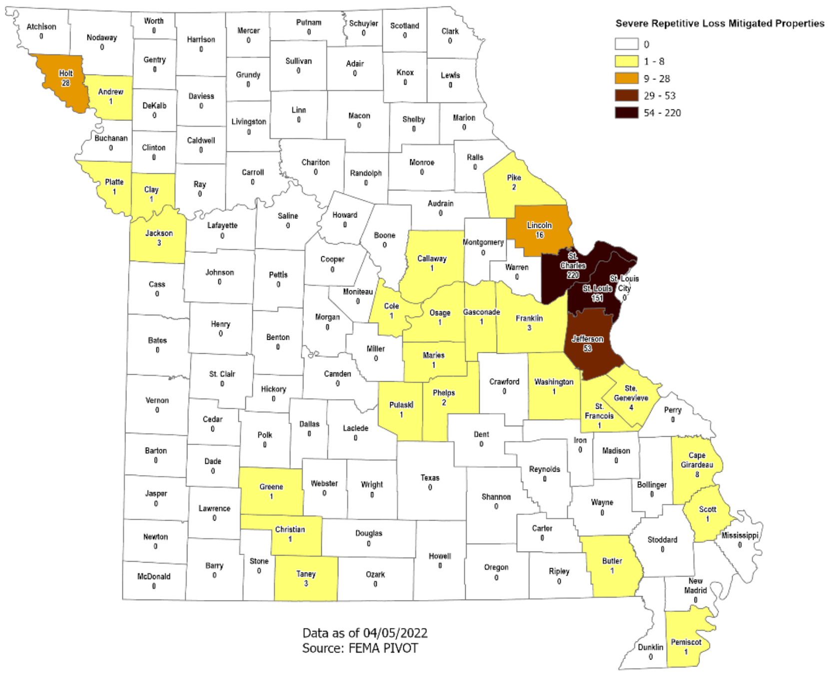
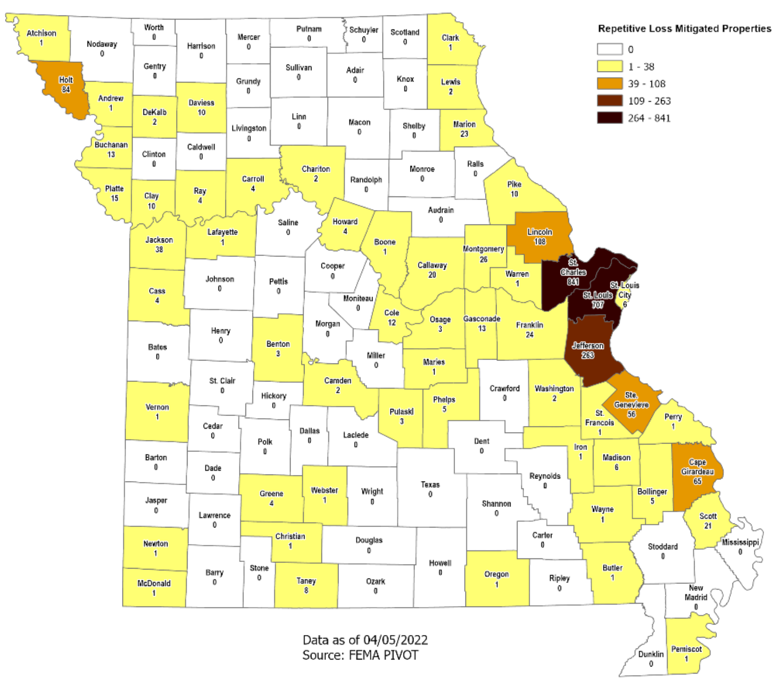


Figure 4.7. Mitigated Repetitive Loss Properties by County



4.3.10. Specific Implemented Actions that Support Reducing Repetitive Flood Loss Properties

In Missouri, there are 6,160 repetitive flood loss properties as of April 2022 (PIVOT). Missouri has already mitigated 2,956 RL and SRL properties since implementing the State's Community Buyout Program. This program has been a huge accomplishment. Almost half the current number of repetitive loss properties have been taken out of harm's way and removed from the flood damage cycle.

There are numerous communities that can be highlighted that have aggressively bought out repetitive flood loss structures. As a "Best Case" example, the City of Arnold purchased 202 single family dwellings and 155 mobile home pads in the floodplain by the end of 1995. They also purchased nine additional homes that had four or more repetitive loss claims paid by NFIP totaling $961,846 by 1995. These additional homes accounted for 43 flood claims, for an average of 4.77 flood claims per property, incurred over roughly a 16-year period. In seven of the nine properties, the NFIP claims paid had already exceeded the fair market value of the properties. In three of those cases, the NFIP claims paid were close to double the fair market value of the properties. Based on those statistics and the potential for more severe flooding events in Missouri, it is possible that the entire $840,000 project cost can be recovered by the NFIP over the next 15-20 years because of losses avoided.

Increased attention to this Repetitive Flood Loss Strategy will be essential to further eliminate RL and SRL buildings from flood damage along with complying with these "Targeted Actions:"

Targeted Action 1: Work with communities through their mitigation planning process to fully understand the causes of repetitive flooding (riverine versus localized stormwater, etc.) including the location of these properties through appropriate mapping of repetitive loss areas so the total repetitive loss problem is addressed and FEMA's Privacy Act of 1974 is not violated.

Targeted Action 2: Enhance the outreach and education on FEMA's HMA Grants programs through additional opportunities to reach communities. Besides the normal web-based approach, consider additional regional workshops and promoting these grant programs through the Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs). Finally, consider a more aggressive outreach approach at state sponsored workshops including providing "Best Case" examples.

Targeted Action 3: Promote Increased Cost of Compliance (ICC) coverage on flood insurance policies as a way for property owners to supplement the HMA Grants or to elevate a building to above the Base Flood Elevation (BFE) for better flood protection and to help reduce repetitive flooding.

Targeted Action 4: Identify communities with RL and SRL properties who have not mitigated any of their buildings (or only a few) and survey them to find out what issues outside of the willingness of the owner to participate in the buyout program are the biggest challenges to participation in the HMA Grant programs.

4.3.11. Funding that Supports Reducing Repetitively Flooded Properties

Section 4.2.4 Review and Progress of Mitigation Actions highlights the yearly funding programs, types of projects, and amounts. Several funding sources have been used in the past for the flood buyout projects: HMGP, FMA, RFC, SRL, and PDM. With the Biggert Water Flood Insurance Reform Act of 2012, the RFC and SRL grant programs were eliminated and rolled into FMA; and with the Disaster Recovery Reform Act (DRRA) of 2018, FEMA introduced a new program, the Building Resilient Infrastructure and Communities Grant Program (BRIC), to replace the PDM Grant Program. Now communities are eligible for funding from HMGP, BRIC, and FMA to fund buyouts or to elevate structures.

Additionally, the DRRA amended Sections 402 and 406 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), and authorized FEMA to “provide assistance to state and local governments for building code and floodplain administration and enforcement, including inspections for substantial damage compliance” and “base and overtime wages for extra hires to facilitate the implementation and enforcement of adopted building codes for a period of not more than 180 days after the major disaster is declared.” Thus, the tracking of cumulative substantial damage and repetitive loss is an eligible activity for communities through the PA program, as well as the implementation of the substantial damage provisions of their local flood hazard mitigation ordinance. Communities will have the opportunity to get a better and fuller picture of the extent of their substantially damaged structures and repetitive loss structures.

SEMA also has a list of questions to help prioritize the distribution of mitigation project funds to local communities, shown in **Section 5.3.2** Federal Project Grants. One bullet item states, “does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties.” Thus, the State seriously considers RL & SRL properties when prioritizing local project funding.

As it is also a priority of SEMA’s Floodplain Management Section to eliminate repetitive loss and severe repetitive loss properties from flood damage, the Section participates with the SHMO in prioritizing structures for mitigation projects and in making the best use of mitigation funding opportunities. This coordination assists the Floodplain Management Section in receiving Community Assistance Program–State Support Services Element (CAP-SSSE) funding to continue to support communities in implementing the requirements of the National Flood Insurance Program (NFIP).

From an implementation perspective, communities with multiple repetitive loss structures that can get the owners to agree with the buyouts or elevation projects are typically the communities that usually pursue grant funding first.

CDBG funds and the Disaster Recovery Supplemental CDBG are also used in Missouri to fund the State’s Community Buyout Program and support mitigating RL and SRL properties. CDBG funds can be used for voluntarily buyouts of residential and non-residential properties.

4.4. Funding Sources

Requirement §201.4(c)(3)(iv): The State mitigation strategy shall include an] identification of current and potential sources of federal, state, local, or private funding to implement mitigation activities.

Missouri utilizes a variety of sources to fund state and local mitigation activities. While most of the funding is from the federal government, additional funding comes from state and local governments.

4.4.1. Primary Federal and State Funding

The State, through SEMA, has instituted an effective and comprehensive all-hazard mitigation program. Through a variety of programs, and the wise use of available federal and state funds, the State has been successful in mitigating areas against the devastating effects of disasters.

FEMA's Hazard Mitigation Assistance programs are the primary sources of current funding for Missouri's mitigation activities. These programs are the Hazard Mitigation Grant Program (HMGP), the Building Resilient Infrastructure and Communities (BRIC) Program, and Flood Mitigation Assistance (FMA) Program. Additional details on the Hazard Mitigation Assistance grants are provided in the State Capabilities Section for SEMA under Hazard Mitigation Assistance (HMA) Grants. SEMA also uses FEMA's Public Assistance Program (Section 406) to implement mitigation activities. Additional details on the FEMA Public Assistance Program are provided in the State Capabilities Section for SEMA under Public Assistance 406 Mitigation. All these grant programs are non-disaster (annually funded) grant programs except the HMGP and Public Assistance Program which are post disaster programs.

Other sources of Federal and State Funding and Technical Assistance

Additional sources of federal and state funding and technical assistance can be found in **Appendix D**. This appendix includes a resource for all state, regional, and local planners trying to find funding for their mitigation activities. Funding Assistance Programs are separated into the following categories:

- General emergency management grants, loans, and assistance
- Floods/flood control grants, loans, and technical assistance
- Earthquake grants, loans, and technical assistance
- All-hazard mapping grants, loans, and technical assistance
- Ancillary flood and natural resource project grants, loans, and technical assistance
- Basic and applied research/development grants
- Other planning resources: Demographics, societal data, and transportation, agricultural, industrial, and economic statistics

4.4.2. Local Funding

Local governments receive most of their funding for mitigation projects from the federal programs discussed above. Other sources of local funding include tax-funded investments (predominantly from property and sales tax) in infrastructure improvements and dedicated transportation/capital improvements sales or use taxes, all of which can also serve to mitigate hazards. A sales tax or bond issue to fund mitigation would require a vote of residents and could be difficult to pass. More information about local funding can be found in **Section 4.6.1** Local Policies, Programs, and Capabilities and **Section 7.5** Effective Use of Available Mitigation Funding.

4.5. State Capability Assessment

Requirement §201.4(c)(3)(ii): The state mitigation strategy shall include a] discussion of the State's pre-and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas; [and] a discussion of State funding capabilities for hazard mitigation projects.

This section discusses Missouri's existing mitigation-related capabilities.

4.5.1. State Agency Capability Assessment

The roles and responsibilities of the Missouri State Emergency Management Agency (SEMA) and the other agencies involved in statewide emergency preparedness, response, recovery, and mitigation activities are outlined below. While each state agency administers its own programs, SEMA provides leadership for the overall state mitigation strategy. The agencies work together to ensure that the various mitigation programs complement each other and work toward achieving the State's overall strategy. One way that agencies work together is by participating on the SRMT, the group responsible for the preparation and review of this plan and for state review of all mitigation initiatives.

The primary existing state and federal programs and planning efforts that guide and regulate hazard mitigation activities are briefly described in this section. This section is organized by administrative agency. A description of each agency's emergency management functions is provided followed by details of the following mitigation-related capabilities, if applicable:

1) Mitigation-related Programs and Initiatives
2) Mitigation-related Outreach and Partnerships
3) Mitigation-related Plans and Reports
4) Mitigation-related Funding Sources

Many of the programs are pre-disaster such as the partnerships, plans, and policies. However, post-disaster capabilities are covered as well, such as the Structural Assessment and Visual Evaluation (SAVE) Coalition, volunteer recovery organizations, State Emergency Operations Plan, and the Drought Response Plan.

State Emergency Management Agency – SEMA

A division within the Department of Public Safety, SEMA is responsible for coordinating statewide emergency preparedness, response, recovery, and mitigation activities among federal, state, and local agencies. The SEMA director is the state coordinating officer during disasters and also serves as the governor's authorized representative and liaison to FEMA; this position is counterpart to the federal coordinating officer. During disaster operations, all departments of state government are expected to cooperate fully with requests for assistance from the SEMA director. The governor's declaration of a state emergency initiates the operation of the State Emergency Operations Plan, which is continually updated by SEMA to meet changing conditions. When the Governor declares a state of emergency in Missouri, SEMA operates the State Emergency Operations Center (SEOC) to lead the disaster response effort.

Preparedness Division

The Preparedness Division works to create coordinated statewide response plans and to provide training for local and state personnel so Missouri effectively responds to emergencies and disasters. The division has responsibility for State Planning, Continuity of Government Planning (COOP), Medical Countermeasures, Strategic National Stockpile, Training and Exercises, Emergency Human Services, Radiological Emergency Program (REP). Examples of division work products include the preparation or update of: comprehensive disaster assistance plans; training of state personnel in disaster recovery and mitigation; and emergency management seminars for local elected officials. It also develops and maintains the State of Missouri Emergency Operations Plan.

- **Emergency Human Services**: Includes the Volunteer Coordinator, who, during disasters works with state agencies, and faith-based and volunteer organizations to coordinate disaster assistance. During recovery, the coordinator provides technical assistance to long-term recovery committees. The coordinator is the point of contact for the Governor's Faith-Based and Community Service Partnership for Disaster Recovery, Missouri Voluntary Organizations Active in Disasters and Missouri Community Organizations Active in Disaster. Together, these organizations are an essential part of Missouri's disaster response and recovery model and acts to enhance the state's ability to plan and prepare for, mitigate, respond to, and recover from any disaster by maximizing public and private resources to facilitate an efficient, integrated system for addressing human services, housing, infrastructure, community and economic development issues.
- **Training and Exercises:** Jurisdictions across Missouri have found that the best way to respond to disasters is by preparing in advance with training activities and using the skills learned to build effective local teams and coalitions. The Emergency Management Training (EMT) curriculum delivered by SEMA offers an extensive array of training opportunities for Missouri state and local emergency managers, public officials, members of volunteer assistance organizations, and professionals in related fields. The EMT program offers comprehensive courses in disaster mitigation, preparedness, response, and recovery.
    - SEMA's Exercise Team: Provides support to local jurisdictions, regional and state agencies, and volunteer and community organizations to design, conduct and evaluate all levels of emergency exercises for threats ranging from local hazmat events to a major earthquake requiring a statewide response.
- **Radiological Emergency Preparedness (REP) Program:** The Radiological Emergency Preparedness Program (REP) develops plans, training, and exercises to assist jurisdictions surrounding commercial nuclear power plants to respond to potential scenarios that might occur.
- **State Planning Program:** The State Planning Program works with local, state, federal, and whole community planning partners to develop and maintain State of Missouri Emergency Operations Plan and the Joint State of Missouri and FEMA Region VII New Madrid Seismic Zone Earthquake Interagency Operations Plan. The State Planning Program is responsible for the development and maintenance of internal SEMA planning documents that include the SEMA Health and Safety Manual and the SEMA Emergency Management Program Five-Year Strategic Plan. The State Planning Program also assists SEMA staff with numerous planning initiatives to help develop planning documents relating to their programs and activities. This includes reviewing

and updating plans and standard operating procedures, developing planning guidance and templates, and participating in exercises to test plans and procedures.

- **Strategic National Stockpile/Medical Countermeasures Program:** The Medical Countermeasures Program manages the planning, receipt, distribution and storage for pharmaceuticals and other medical supplies and equipment necessary to respond to a major emergency or disaster when local supplies may become depleted. These supplies are provided through the federal Strategic National Stockpile (SNS) program, a national repository of critical drugs and medical supplies designed to supplement and resupply state and local public health agencies and hospitals in a major emergency. The goal is to deliver SNS lifesaving pharmaceuticals to any location within 12 hours once the federal decision to deploy is made.

- **Mass Fatality Program:** The State of Missouri has the capacity to deploy and support disaster mortuary activities from events resulting in over 200 fatalities without federal support; while having the ability to process the remains of between 20-40 individuals (depending upon condition), in a 24-hour period. Specialized personnel are experts in their respective fields and can be deployed anywhere in the State in as little as 4-6 hours. Specialized equipment, including the state-of-the-art Disaster Portable Morgue Unit, can be deployed in 24-hours or less. The Missouri Mortuary Operations Response Team (MOMORT-1) maintains readiness through a robust schedule of training and exercises, and stands ready to deploy at all times.

- **Missouri Disaster Chaplaincy Program:** The Missouri Disaster Chaplaincy Program coordinates and support the identification, deployment, transportation, and demobilization of Chaplain resources required in response to a broad suite of disasters—large and small—that affect the health of our communities.

- **Emergency Management Accreditation Program (EMAP):** EMAP is a voluntary assessment and accreditation process for state emergency management programs. Accreditation is granted only following a rigorous peer review of all aspects of a state's emergency management program. See **Section 2.3.3** and **Appendix C** for additional information.

- **Continuity of Operations:** The Continuity of Operations Program has the primary responsibility for providing planning guidance, assistance, and coordination to state departments, agencies, and local governments in the development and maintenance of continuity of operations plans. The program oversees maintenance of SEMA's Continuity of Operations plan. Continuity of Operations plans have been developed for all 16 Executive departments and the Judiciary. SEMA provides planning and technical assistance to local jurisdictions to develop and maintain continuity of operations plans.

- **Public Health Emergency Preparedness/Hospital Preparedness Program:** SEMA Program staff help manage and support the Missouri Disaster Medical Assistance Team (MO DMAT-1), the Missouri Mortuary Operations Response Team (MO MORT-1), Medical Countermeasures Measures (Strategic National Stockpile) Program, Show-Me Response Volunteer Registry, Medical Reserve Corps (MRCs), the Missouri Disaster Chaplaincy Program, as well as various on-going public health and medical projects. These programs are funded via a contract through the Missouri Department of Health and Senior Services (DHSS). Federal funding is administered through cooperative agreements by the U.S. Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC) and the Assistant Secretary for Preparedness and Response (ASPR).

- **<u>State Disaster Recovery Framework:</u>** The Missouri Disaster Recovery Framework (MDRF) is the result of a collaborative effort across state agencies to enhance the long-term recovery capabilities of the State of Missouri and its partners, communities, and citizens before and after disasters of all types. The State Disaster Recovery Coordinator (SDRC) coordinates with local communities and state and federal agencies to plan for long-term recovery from disasters and other adverse events, strengthen recovery core capabilities, build resilience, assess impacts post event, and coordinate recovery efforts. The SDRC focuses on incorporating recovery and mitigation considerations into the early decision-making processes and manages a unified communications strategy for recovery.

Response Division

The Response Division is responsible for disaster management operations whenever Missouri is affected by an emergency or disaster that may be beyond the capabilities of local governments and includes the Statewide Regional Coordinators, Readiness, and Logistics and Resources sections. Once a state of emergency (SOE) has been declared by the Governor, the Response Branch opens the State Emergency Operations Center (SEOC) and coordinates disaster response with local governments, state agencies, the Missouri National Guard faith-based and volunteer agencies, private sector partners and FEMA. The branch also develops emergency operations procedures for state and local governments, and assists local governments in the development of emergency response capabilities.

- **<u>Statewide Regional Coordinators:</u>** SEMA's Regional Coordinators are the state's liaisons to local jurisdictions for emergency management activities. They assist local jurisdictions in all aspects of emergency management, including emergency operations plan development and revision, training and exercises. The state of Missouri is divided into nine regions, A-I, which correspond with the Missouri State Highway Patrol troops. The nine regional coordinators provide assistance to Missouri's 114 counties and their associated jurisdictions, and the independent City of St. Louis.

- **<u>Readiness Section:</u>** The Readiness Section is responsible for developing comprehensive emergency operations plans and procedures for state and local governments. The section also assists local governments in developing and improving their emergency response capabilities and includes the SEMA Watch Center and is SEMA's WebEOC contact.

- **<u>Logistics and Resources Section</u>:** The Logistics and Resources Section focuses on coordinating the delivery of key emergency life-saving and life-sustaining equipment, the provision of essential services and critical supplies to disaster areas. These supplies may include generators, pumps and other flood fighting materials, technical assistance teams, food, water, ice, and any temporary facilities that may be required. Logistics and Resources, along with the Missouri Public/Private Partnership (MOP3), also co-manages the Missouri Business Emergency Operation Center (BEOC). The BEOC provides for the exchange of situational awareness to the business community. The Field Services Section oversees SEMA's Area Coordinators, who are the state's liaisons to local jurisdictions for emergency management activities.

Recovery Division

When a disaster occurs that may require response and recovery efforts beyond the capabilities of the state and local jurisdictions, the Recovery Division coordinates and conducts damage surveys with local and federal agencies and prepares, at the Governor's direction, a federal disaster declaration request. Following a federally-declared disaster, the division is responsible for working with local and federal

agencies to request and distribute federal and state funds for all recovery projects and eligible response expenditures. The division also works to coordinate efforts to mitigate against disasters and administers federal mitigation grants. The division is composed of the Public Assistance, Floodplain Management and Mitigation sections.

- **Public Assistance Section:** Public Assistance Section responsibilities include state damage assessments; assistance in revising State Administrative Plans for Public Assistance and oversight of the FEMA Individuals and Households Program. The State Public Assistance program administers federal grants to eligible public entities for emergency protective measures, debris removal, and the repair, restoration or rebuilding of damaged public facilities in federally-declared disaster areas. Such entities include state agencies, local governments, and certain private, non-profit organizations.

- **Floodplain Management Section:** The Floodplain Management Program administers the National Flood Insurance Program (NFIP) for the state of Missouri. Additional information on this is provided below under Mitigation-related Programs and Initiatives.

- **Mitigation Section:** The Mitigation Section works with local communities to reduce or avoid the adverse impacts of disasters through the administration of the federal hazard mitigation grant program and assists Missouri counties to write mitigation plans to qualify for these grants. Community mitigation projects include voluntary flood buyouts, the replacement of community owned bridges and low water crossings, creek bank stabilization and "re-channelizing" streams to lessen the threat of future flooding. In recent years, mitigation funding has been used increasingly to protect Missourians from tornadoes and severe windstorms by constructing school and community tornado safe rooms across the state. Additional information is provided below under Mitigation-related Programs and Initiatives.

- **Floodplain Engineering and Mapping Section:** The Floodplain Engineering and Mapping Section administers the Risk MAP program and Cooperating Technical Partners program.

- **Interagency Recovery Coordination Section:** Oversees interagency long-term recovery coordination operations as related to federally declared disasters and non-federally declared disasters.

Fiscal Division

- **Emergency Management Performance Grant (EMPG) Program** – The EMPG Program provides federal assistance to SEMA and local government emergency management agencies for the sustainment and enhancement of all-hazard emergency management capabilities. An all-hazard approach to emergency response, including the development of a comprehensive program of planning, training and exercises, supports an effective and consistent response to disaster and emergencies, regardless of the cause. It involves building long-term strategic relationships within the emergency management community.

- **Fiscal Administration Section** – The Fiscal Administration Section provides administrative services such as accounting, budgeting, grant administration, procurement, fleet management, human resources, payroll, and general office services. The Section coordinates and administers federal, state and local grant requests.

Missouri Emergency Response Commission (MERC):

The Missouri Emergency Response Commission's (MERC) mission is to protect public health and the environment by assisting communities with chemical incident prevention, preparedness, response and recovery. MERC implements the federal Emergency Planning and Community Right-to-Know Act (EPCRA) and related Missouri laws pertaining to hazardous chemicals storage. The commission supports local emergency planning committees (LEPC), reviews hazardous chemical contingency plans, provides chemical emergency training, collects information on toxic and hazardous storage and makes this information available to the public. MERC administers the Hazardous Material Emergency Preparedness (HMEP) for hazardous material (HAZMAT) training to local public-sector employees and the Chemical Emergency Preparedness Funds (CEPF) for planning and training for LEPCs.

Mitigation-Related Programs and Initiatives

There are several programs administered by SEMA related to various aspects of development and implementation of the mitigation strategy in the State.

Mitigation Management

SEMA's Mitigation Management Section works with local communities to reduce or avoid the adverse impacts that disasters have on Missourians. Hazard mitigation is any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards and their effects. This definition distinguishes actions that have a long-term impact from those that are more closely associated with immediate preparedness, response, and recovery activities. Hazard mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage, reconstruction, and repeated damage. Community mitigation projects range from voluntary flood buyouts to building community tornado safe rooms; replacing county- and community-owned culverts and low water crossings; stabilizing stream banks; and burying public electric utilities.

Missouri Floodplain Management/Floodplain Insurance Programs

The Floodplain Management Section administers the NFIP for the state of Missouri. Most homeowner insurance policies do not cover flood damage, so the purchase of specific flood insurance may be necessary. For those who live in a mapped high-risk Special Flood Hazard Area (SFHA), federal law requires federally backed mortgage lenders to require the purchase of flood insurance. This section works with NFIP-participating communities to ensure they comply with the requirements of the program, which provides nearly $4 billion in flood insurance coverage for homes and businesses in Missouri. This section also works with the US Army Corps of Engineers (USACE) Silver Jackets to educate communities on flood risk mitigation actions which can improve their CRS score for reduced cost insurance premiums. SEMA is also a Cooperating Technical Partner (CTP) with FEMA in the production of Digital Flood Insurance Rate Maps (DFIRM) under the federal "Risk MAP" program. In addition, the section partners with the Missouri Floodplain and Stormwater Managers Association (MfSMA) and others to offer NFIP training for local floodplain managers, planners, insurance agents, elected officials, engineers and surveyors, lenders and realtors.

Training and Exercises

The Emergency Management Training (EMT) curriculum delivered by SEMA offers an extensive array of training opportunities for Missouri state and local emergency managers, public officials, members of volunteer assistance organizations, and professionals in related fields. The EMT program offers comprehensive courses in disaster mitigation, preparedness, response, and recovery. Jurisdictions

across Missouri have found that the best way to respond to a disaster is by preparing in advance with training activities and using the skills learned to build effective local teams and coalitions.

Earthquake Program

The Earthquake Program informs Missourians about the earthquake risk associated with the New Madrid Seismic Zone and recommends safety and mitigation steps that can be taken to prepare for earthquakes and their potential consequences.

High Hazard Potential Dams Program (HHPD)

On December 16, 2016, the Water Infrastructure Improvements for the Nation Act or the "WIIN Act," was signed, which adds a new grant program under FEMA's National Dam Safety Program (33 U.S.C. 467f). Section 5006 of the Act, Rehabilitation of High Hazard Potential Dams, provides technical, planning, design, and construction assistance in the form of grants for rehabilitation of eligible high hazard potential dams.

To address this new program, a new mitigation action was added by the SRMT for SEMA and the MoDNR to hold quarterly meetings to discuss the High Hazard Potential Dams Program (HHPD). Discussions will include vulnerabilities and consequences, dam incidents, deficiencies, mitigation actions, challenges, possible solutions to lack of resources to administrating the HHPD grant.

Radiological Emergency Preparedness (REP) Program

The Radiological Emergency Preparedness Program (REP) develops plans, training, and exercises to assist jurisdictions surrounding commercial nuclear power plants to respond to potential scenarios that might occur.

State Planning Program

The State Planning Program has primary responsibility for providing planning guidance and assistance to state departments, agencies, and local governments so that they can develop and maintain all-hazard (e.g. tornadoes, severe weather, flooding) emergency operations plans (EOPs) and others.

SAVE Coalition

The Missouri Structural Assessment and Visual Evaluation (SAVE) Coalition is a group of volunteer engineers, architects, building inspectors and other trained professionals that assists the Missouri State Emergency Management Agency with building damage inspections. After a disaster, SAVE volunteers are trained to move quickly to determine which buildings are safe to use and which should be evacuated.

Statewide Regional Coordinator Program

SEMA's Regional Coordinators are the state's liaisons to local jurisdictions for emergency and disaster management activities. They assist local jurisdictions in all aspects of emergency management, including emergency operations plan development and revision, training and exercises. The state of Missouri is divided into nine regions, A-I, that correspond with the Missouri State Highway Patrol troops. Ten Regional coordinators provide assistance to Missouri's 114 counties and their associated jurisdictions, and the independent City of St. Louis.

State Public Assistance Program

The State Public Assistance program provides an organizational structure for the administration of federal grants to eligible public entities for the repair and restoration of damaged public facilities within a federally-declared disaster area. Such entities include state agencies, local governments, and certain private, non-profit organizations.

Individuals and Households Program
The Individuals and Households Program (IHP) program provides state-federal assistance to individuals and families for uninsured critical emergency needs when authorized in a federally-declared disaster.

Mitigation-related Outreach and Partnerships

State Risk Management Team
The State Risk Management Team has evolved over time to its current make-up and function. During the 1993 Midwest floods, an interagency hazard mitigation team was formed that was composed of representatives from FEMA, SEMA, USACE and various state agencies and departments (i.e., Governor's Office, Department of Economic Development, Department of Natural Resources, Department of Transportation). The wisdom in this approach can be found in the results. Only six months after hazard mitigation funding became available, all projects were approved. Subsequent disasters were also coordinated and managed by the Interagency Hazard Mitigation Team (IHMT). The state members of the IHMT would later make up what is today the State Risk Management Team. The group is also responsible for the monitoring, evaluation, and updating of this plan. More information on the participants and responsibilities of the SRMT can be found in **Section 2** Planning Process.

Mitigation Management Website
The SEMA Mitigation Management Website provides a platform for providing documents and resources related to the Hazard Mitigation Assistance Grants as well as Hazard Mitigation Planning. It is located here: https://sema.dps.mo.gov/programs/mitigation_management.php.

Floodplain Management Website
SEMA has developed a comprehensive floodplain management website to disseminate information to local floodplain managers, CEOs, emergency management personnel and the general public. This website, located at www.sema.dps.mo.gov/programs/floodplain/ includes basic NFIP information, forms used to manage development in the floodplain, information on upcoming training workshops, information on CFM training and exams, and related website links.

Risk MAP Global Outreach Plan
Each year, with implementation of Risk Mapping, Assessment, and Planning (Risk MAP), a Global Outreach Plan is developed that outlines the outreach efforts to communicate goals, activities, and programs related to floodplain management.

Risk MAP Outreach Website
SEMA has developed an online flood visualization tool to present the Risk MAP regulatory and non-regulatory mapping products. This outreach tool is a web-based flood visualization/awareness tool that integrates digital flood hazard data in an online mapping environment to provide specific information to communities and stakeholder agencies regarding Risk MAP efforts and products. Through this website, located at http://bit.ly/MOSEMAOutreach, users can access available data layers and apply them to a web-viewer of aerial imagery or street map data for Risk MAP study areas. This tool provides a clearinghouse of flood hazard information for use by developers, the insurance industry, government agencies, and the public as well as assist the State and local governments in their mitigation planning, floodplain management, and flood response efforts.

Public Information Program
The public information coordinator in SEMA's Executive Branch produces public awareness campaigns on a variety of natural hazards for local emergency management agencies to distribute to their media.

News releases on SEMA programs and disaster response activities are distributed electronically and posted on the SEMA web site.

The Call Newsletter

The Call is Missouri's Show-Me Response Program newsletter, produced quarterly by the Missouri State Emergency Management Agency's Emergency Human Services section. The Call provides news and information to affiliated volunteers about volunteer opportunities, best practices, trends and issues touching volunteer efforts.

Emergency Management Conference

The SEMA/Missouri Emergency Preparedness Association (MEPA) Conference is an annual event and includes workshops on a variety of subjects, one of which addresses the mitigation program. MEPA helps coordinate emergency management officials and serves as a clearinghouse for ideas and actions to protect lives and properties in Missouri from natural and manmade disasters. Past topics of the conference have included the mitigation planning process, risk assessment, identification and development of viable mitigation projects, benefit-cost analysis, and public-private partnerships. Federal, state, and local emergency management officials; state and local elected representatives; business and industry representatives; and representatives from volunteer organizations are invited to attend.

Annual Missouri Floodplain and Stormwater Manager's Conference (MfSMA)

SEMA supports, organizes, and sponsors the Missouri Floodplain and Stormwater Managers Association's annual conference. This event features the Certified Floodplain Manager Exam (and review) and seminars on topics such as the National Flood Insurance Program, floodplain mapping, and stormwater utilities. Speakers represent a variety of partner agencies and organizations (e.g., the Departments of Natural Resources and Conservation have given seminars on low impact design, which is based on the no adverse impact philosophy). SEMA staff also attend the annual Association of State Floodplain Managers conference.

Trainings and Workshops

SEMA mitigation staff schedule and conduct various trainings and workshops throughout the year to increase knowledge and understanding of mitigation and floodplain management. A few examples are bulleted below:

- Recovery from Disaster: The Local Community Role – this course covers foundational concepts in disaster recovery and the latest guidance on recovery planning. Participants assess their own recovery plans against national planning guidance.
- Tools of Floodplain Management—this workshop is a 2-day course designed for local floodplain administrators. It covers various important issues as well as day-to-day activities. This course is designed to provide basic knowledge of the National Flood Insurance Program (NFIP).
- Disaster Management for Water and Wastewater Utilities – this course is designed to provide training to water and wastewater professionals on issues concerning preparing for, responding to, and recovering from natural or human-caused disasters that threaten water and wastewater facilities and systems.
- Certified Floodplain Manager (CFM) Training—these trainings, typically offered three times throughout the year provide training as well as administration of the exam to receive Certified Floodplain Manager Certification.

Regional Planning Commissions

SEMA has very successful partnerships with the state's 19 Regional Planning Commissions/Councils of Governments (RPCs). SEMA equips these partners in mitigation with tools, training, and technical support to help local governments meet state and federal mitigation requirements. Specific services the RPCs provide to local governments include local mitigation plan development and GIS support. RPCs also assist the state with the approval of local plans. Because of their involvement in local plan development, the RPCs are more cognizant of mitigation, can convey their knowledge to the local communities, and can consider the basic principles of mitigation in their other planning efforts, including transportation, comprehensive, and capital improvement planning.

Ready in 3 Program

The Ready in 3 Program provides tools and materials free of charge to schools and families in Missouri for taking steps to provide for emergency situations. The program was developed by the Missouri Department of Health and Senior Services with endorsement from SEMA and the American Red Cross.

Central United States Earthquake Consortium

Since 1983, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee have been members of the Central United States Earthquake Consortium (CUSEC), which was formed to improve public earthquake awareness and education; coordinate multistate planning for earthquake mitigation, preparedness, response, and recovery; and encourage research in earthquake hazard reduction. The earthquake program managers and state emergency management directors of the member states meet at least twice annually with CUSEC management and FEMA's regional earthquake program managers to formulate earthquake safety and mitigation programs and projects. Soils mapping developed by CUSEC was used in the HAZUS-MH models for the 2007 update of this plan.

University of Missouri Extension

The University of Missouri Extension uses science-based knowledge to help people understand change, solve problems, and make informed decisions on a wide variety of topics. The extension's Community Emergency Management Program provides education and technical assistance to individuals and families, local governments, businesses, schools, and organizations in preparing and responding to natural and manmade disasters.

Mitigation-related Plans and Reports

State Hazard Mitigation Plan

SEMA coordinates the development of the State Hazard Mitigation Plan (this plan) which must be revised and reviewed/approved by FEMA on a 5-year cycle. The purpose of this plan is to complete a risk and capability assessment as well as provide guidance, direction and prioritization for mitigation activities in the State. The plan contains an analysis of Missouri's hazards, risks and vulnerabilities, describes the manner in which mitigation is planned, programmed and carried out, and establishes the hazard mitigation goals, objectives and recommended actions and initiatives that will reduce injuries, damages, and loss of life caused by disasters.

State Emergency Operations Plan

Updated regularly, the State Emergency Operations Plan lays a framework that will allow the State of Missouri to save lives, minimize injuries, protect property and the environment, preserve functioning civil government, ensure constituted authority, and maintain essential economic activities in the event of an emergency or disaster, natural, technological, or otherwise. Specifically, it directs the actions of state departments and agencies in response to a variety of incidents where local need and suffering

requires state assistance. Authority for the plan is set forth in Code of State Regulations 11 CSR 10-11.010, Chapter 44, Revised Statute of Missouri.

This plan emphasizes a comprehensive approach to emergency management that strives to integrate all hazards that pose a risk to the State, all phases of emergency management, and all levels of government and the private sector. Additionally, the SEOP institutionalizes the concepts and principles of the National Incident Management System and the Incident Command System into response and recovery operations conducted within the State of Missouri. It also sets the parameters for the development of local emergency operations plans and procedures.

This functional plan consists of three components: 1) The Basic Plan is the overall guide for state emergency management activities. It contains the policies and regulations that govern emergency management and assigns responsibilities for the execution of emergency functions to various state agencies and private organizations. 2) The functional annexes provide specific direction for the essential emergency functions outlined in the Basic Plan. Functions addressed by the 25 annexes include warning, damage assessment and analysis, evacuation, hazardous materials, disaster recovery, continuity of government, terrorism, and special needs. 3) Supporting documents explain how actions are to be carried out in support of each functional annex. Supporting documents include maps, charts, and resource lists that help organizations carry out their emergency responsibilities.

Threat and Hazard Identification and Risk Assessment (THIRA)

SEMA updates the THIRA annually in accordance with the Comprehensive Preparedness Guide 201. The purpose of this plan is to:

1) Identify the Threats and Hazards of Concern. Based on a combination of past experience, forecasting, expert judgment, and other available resources, communities identify a list of the threats and hazards of primary concern to the community.
2) Give the Threats and Hazards Context. Communities describe the threats and hazards of concern, showing how they may affect the community.
3) Establish Capability Targets. Communities assess each threat and hazard in context to develop a specific capability target for each relevant core capability. The capability target defines success for the capability.
4) Apply the Results. Communities estimate the required resources per core capability to meet the capability targets.

Mitigation-related Funding Sources

Hazard Mitigation Assistance (HMA) Grants

Under the Hazard Mitigation Assistance Grants, SEMA administers three FEMA funding programs that provide funding for eligible mitigation planning and projects that reduce disaster losses and protect life and property from future disaster damages. The three programs are:

- Hazard Mitigation Grant Program
- Building Resilient Infrastructure & Communities
- Flood Mitigation Assistance Program

The Hazard Mitigation Grant Program (HMGP)

Authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (the Stafford Act), Title 42, United States Code (U.S.C.) 5170c. The key purpose of HMGP is to

ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster. HMGP is available, when authorized under a Presidential major disaster declaration, in the areas of the State requested by the Governor.

Amount: Federal funding under the HMGP is available following a major disaster declaration if requested by the governor. The amount of an HMGP grant will depend on the costs associated with each individual disaster. Since the Missouri State Hazard Mitigation Plan is an enhanced plan, the State is eligible for up to 20 percent of the total estimated federal assistance provided after a major disaster declaration. States with standard hazard mitigation plans are eligible for 15 percent for amounts not more than $2 billion, 10 percent for amounts of more than $2 billion and not more than $10 billion, and 7.5 percent on amounts more than $10 billion and not more than $35.3 billion.

Eligibility: HMGP funds are administered by SEMA. Local governments, eligible private non-profit organizations or institutions, and Indian tribes or authorized tribal organizations are eligible to apply to SEMA for assistance as subapplicants. Individuals and businesses are not eligible to apply to the State, but eligible local governments or private non-profit organizations may apply on their behalf. The SEMA mitigation administrative plan sets out the method for prioritization and review of applications. After SEMA review and determination, selected subapplications are sent to FEMA for review and approval. For project grants, subapplicants must have a FEMA-approved local mitigation plan. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

Cost-Share Requirements: HMGP funds are provided on a 75 percent federal/25 percent nonfederal cost share basis. The nonfederal match does not does not need to be cash; in-kind services and/or materials may be used.

Building Resilient Infrastructure and Communities (BRIC) Program

Since the Disaster Recovery Reform Act of 2018 was signed into law, FEMA has developed the Building Resilient Infrastructure and Communities (BRIC) program to address National Public Infrastructure Pre-Disaster Hazard Mitigation (Provision 1234).

Amount: BRIC is a competitive grant program that provides funding for mitigation projects to reduce the risks from disasters and natural hazards. The amount of funding is based on a 6% set-aside of the assistance FEMA provides following major disaster declarations through the Public Assistance and Individuals and Households Program. The BRIC program was designed to foster innovation and provides a yearly grant cycle offering applicants a consistent source of funding.

Eligibility: In Missouri, SEMA serves as the applicant for all BRIC grants. State-level agencies, including state institutions (e.g., state hospital or university); federally recognized Indian tribal governments; local governments (including state recognized Indian tribes and authorized Indian tribal organizations); public colleges and universities; and Indian Tribal colleges and universities are eligible to apply to SEMA for assistance as subapplicants. Subapplicants must have a FEMA-approved Local or Tribal Hazard Mitigation Plan. SEMA reviews and prioritizes subapplications and submits the grant application with subapplications to FEMA for review and approval.

Cost-Share Requirements: BRIC funds are generally provided on a 75 percent federal/25 percent nonfederal cost share basis. The nonfederal match does not need to be cash; in-kind services and/or materials may be used. Economically disadvantaged rural communities, also known as small impoverished communities, are eligible for non-federal cost share, up to 90%/10%.

The Flood Mitigation Assistance (FMA) Program

Authorized by Section 1366 of the National Flood Insurance Act of 1968, as amended (NFIA), 42 U.S.C. 4104c, with the goal of reducing or eliminating claims under the NFIP.

Amount: Congress appropriates funds annually for this program. FMA grants are awarded on a competitive basis. Eligible subapplications will compete nationally for FMA grant funds.

Eligibility: In Missouri, SEMA serves as the applicant for all FMA grants. State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance as subapplicants. Individuals and private nonprofit organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SEMA reviews and prioritizes subapplications by the applications that include mitigating repetitive loss properties. SEMA then submits the grant application with subapplications to FEMA for review and approval.

All subapplicants must be participating and in good standing in the NFIP. Also, properties included in a project subapplication must be NFIP-insured at the time of the application submittal. For project grants, subapplicants must have a FEMA-approved flood mitigation plan or multi-hazard mitigation plan that meets FMA planning requirements. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

Cost-Share Requirements: FMA funds are generally provided on a 75 percent federal/25 percent nonfederal cost share basis. The recipient must provide the 25 percent match, only half of which may be in-kind contributions. For severe repetitive loss properties, FEMA may contribute up to 100 percent of the total eligible costs and up to 90 percent of the total eligible costs for repetitive loss properties if the State has taken actions to reduce the number of severe repetitive loss/repetitive loss properties and has an approved state mitigation plan that specifies how it intends to reduce the number of severe repetitive and repetitive loss properties.

Public Assistance 406 Mitigation

Program Summary: Section 406 (Public Assistance) of the Stafford Act establishes the program for the repair, restoration, and replacement of facilities damaged as a result of a presidentially declared disaster. For damaged facilities, these funds can be used for hazard mitigation measures determined to be necessary to avoid future damage. Section 406 mitigation funds can only be used in the declared disaster areas (usually counties) and only in conjunction with identified, eligible disaster projects that will strengthen existing infrastructure and facilities to more effectively withstand the next disaster. One example would be replacing a blown-out culvert with one designed to convey higher flows, instead of one that will be easily damaged in a flood again.

Eligibility: State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance.

Cost-Share Requirements: Public Assistance grants are provided at not less than 75 percent federal/25 percent nonfederal cost share basis for emergency measures and permanent restoration. All projects approved under State disaster assistance grants will be subject to the cost sharing provisions established in the FEMA-State Agreement and the Stafford Act.

Attorney General's Office

The Attorney General's Office represents the legal interests of the State and its agencies. The Attorney General's Office did not report any mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Agriculture

The Missouri Department of Agriculture sets agriculture policy and provides assistance to farmers throughout the State. The Department of Agriculture is involved specifically with drought mitigation and mitigating agricultural damage from other hazard events.

Mitigation-Related Plans and Reports

Catastrophic Mortality and Associated Material Disposal, October 2008

This plan describes the outcome of a foreign animal disease outbreak or other natural or man-made disaster where Missouri livestock and poultry producers could be faced with the task of large-scale mortality and the disposal of other potentially contaminated materials associated with the foreign animal disease response and mitigation.

Department of Conservation

The Missouri Department of Conservation (MDC) is active in the State Emergency Operations Center (SEOC), during all state declared disasters. MDC has work teams and equipment throughout the State which provide assistance to cities, counties, and other state agencies as necessary during disasters. MDC also participates in all pre-disaster exercises, drills, and planning teams in the State.

MDC owns many undeveloped floodplain areas that provide storage during high flows. The MDC is also a member of numerous levee districts that provide flood protection to crops and structures. All lakes owned by the Department of Conservation with dams over 35 feet high are designed in accordance with the criteria of the Dam and Reservoir Safety Council of Missouri. The safety or redundancy factor built into these dams and levee construction projects is a higher standard than for commercially constructed projects. In addition, the department owns facilities for launching and landing boats that regularly flood and are designed to be "low profile" and relatively flood-proof.

MDC also participates in a statewide wildfire control program in cooperation with the forest industry, rural fire departments, and other agencies. Prescribed burning of prairies, glades, and savannas may increase the risks of fire hazards; however, prescribed burning reduces the availability of fire fuels and the potential for future, more serious fires to develop. The Department of Conservation, in coordination with SEMA, also performs endangered species reviews for proposed FEMA-funded mitigation projects.

Mitigation-related Programs and Initiatives

Missouri Department of Conservation (MDC) Statewide Wildfire Control Program

Wetland Reserve Easement Program

MDC works with the USDA to help administer the Wetland Reserve Easement Program. The program offers technical guidance for restoring and maintaining wetlands and financial assistance to qualifying landowners.

Wetland Planning Initiatives

The Wetland Planning Initiative is a guide for how MDC approaches wetland management. It's grounded on science-based methods and the importance of working with partners and citizens across the state. MDC is committed to first-rate management of the wetlands in its care and to building partnerships with other groups and private landowners to bring wetland conservation to local agriculture, businesses, and communities.

Mitigation-related Funding Sources

Community Conservation Funding Opportunities

The Department of Conservation offers communities and partners a number of grant and cost-share options to assist with everything from green development to wildlife habitat to enhancing outdoor recreation opportunities.

Department of Economic Development

The Department of Economic Development (DED) administers the Community Development Block Grant program (CDBG) which can provide funding for hazard mitigation and disaster recovery. The DED also administers programs for "distressed and targeted" communities.

Mitigation-related Funding Sources

Community Development Block Grant – Emergency

This program provides assistance to communities to address conditions that pose a serious and immediate threat to the health and welfare of the community. The need must be a serious threat to health or safety, be immediate, have developed or greatly intensified within the past 18 months, and be unique in relation to the problem not existing in all other communities within the state.

Grow Missouri Disaster Loan Program

To provide financial assistance and access to capital businesses and nonprofits directly impacted by flooding or tornados, located in disaster areas in the State. No new authorizations may be made for this program. Existing projects with previous authorizations may complete their projects and may still achieve the program benefits subject to the program rules and any terms and conditions of their original award.

HUD National Disaster Resilience Competition

In 2016, the National Disaster Resilience competition made $1 billion available to communities that had been struck by natural disasters in recent years. The competition promoted risk assessment and planning and funded the implementation of innovative resilience projects to better prepare communities for future events. Funding for the competition was from the community Development Block Grant disaster recovery appropriation provided by the Disaster Relief Appropriations Act, 2013 (PL 113-2). This competitive grant was administered in Missouri by the Department of Economic Development.

Small Business Disaster Loan Program

Provides financial assistance and access to capital to businesses located in any county that has been declared a federal disaster area or identified by the United States Small Business Administration as a county impacted by a natural disaster.

Mitigation-related Plans and Reports

Missouri Consolidated Plan

In 1995, the Consolidated Plan became the single planning document for all funds received by the State from the U.S. Department of Housing and Urban Development (HUD) including CDBG. The State's housing, community development, and economic development needs are outlined in the Consolidated Plan.

Department of Elementary and Secondary Education

The Department of Elementary and Secondary Education is within the Missouri State Board of Education. According to the Missouri Constitution, "The supervision of instruction in the public schools shall be vested in a state board of education ..." (Article IX, Section 2a). This provision gives the State Board of Education general authority for public education, within limits set by the General Assembly. The Board's major responsibilities include defining academic performance standards and assessment requirements for public schools; accrediting local school districts, establishing requirements for the education, testing, assessment, certification and recertification of all public school teachers and administrators; operating the Missouri School for the Blind (St. Louis), the Missouri School for the Deaf (Fulton), and the statewide system of Missouri Schools for the Severely Disabled; as well as overseeing federal education programs and the distribution of federal funds to school districts.

Mitigation-related Programs and Initiatives

Child Care Subsidy Program – Disaster Plan

Department of Social Services (DSS), Children's Division (CD) coordinates with the Missouri State Emergency Management Agency (SEMA) during disaster events. This document is developed to support the Child Care Subsidy Program infrastructure in Missouri with continued assistance to emergency solutions due to disaster related events.

Department of Health and Senior Services

The Department of Health and Senior Services (DHSS) has internal emergency response plans in place, and as part of the State response the Missouri State Emergency Operations Plan has been fully tested with exercises for all aspects of response and recovery including those relating to public health, emergency response, terrorism, biological, chemical, and radiological/nuclear threats, pandemic influenza, and natural disasters. The Missouri Center for Emergency Response within the DHSS is responsible for coordinating regional and state planning for public health emergencies and disasters, including biological, chemical, and nuclear terrorism. Through partnerships with hospitals and other healthcare organizations; local entities including law enforcement agencies; and other partners, the center works to assure systems are in place to protect the health of Missourians during a public health emergency. The department also has responsibility for planning related to the Center for Disease Control and Prevention's Strategic National Stockpile, which provides life-saving medications and supplies in the event of a large health catastrophe.

The Division of Community and Public Health (DCPH) is responsible for areas of surveillance, disease investigation, and environmental public health. In order to further detect and analyze events of public health importance, DHSS has enhanced surveillance programs through the Public Health Emergency Preparedness grants. The Public Health Event Detection and Assessment Unit in DCPH manages the BioTerrorism Surveillance System and the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE) to provide for early event detection. The ESSENCE system works by placing chief complaints from each emergency department visit into one or more syndromic groups.

The system then determines whether the number of visits in the syndromic category was higher than expected for that hospital, county, or zip code. The system can also be used to increase situational awareness by augmenting information about a known health event and its consequences.

Mitigation-related Programs and Initiatives

Missouri Pandemic Influenza Response Plan, 2020

This plan is designed primarily to guide the operational components of the state response to pandemic influenza in Missouri. This plan is not intended to describe the processes for stopping a pandemic, but rather to describe strategies of preparedness, response, and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., levels that do not overwhelm the critical infrastructures of the state), and to promote community resiliency and rapid recovery.

Ready in 3 Program

Provides tools and materials free of charge to schools and families in Missouri for taking three steps you can take to prepare for many kinds of emergency situations. The program was developed by the Missouri Department of Health and Senior Services with endorsement from SEMA and the American Red Cross.

Show-Me Response

Is the online registration system for health professionals to volunteer to provide services during a disaster and/or emergency situation.

Medical Reserve Corps (MRC)

The Medical Reserve Corps (MRC) is a national network of local groups of volunteers committed to improving the health, safety and resiliency of their communities. MRC units identify, screen, train and organize the volunteers, and utilize them to support routine public health activities and augment preparedness and response efforts.

Department of Higher Education

At the direction of the Coordinating Board for Higher Education (CBHE), the Missouri Department of Higher Education and Workforce Development (MDHEWD) strives to coordinate higher education policy that fosters a quality post-secondary system, as well as increase participation in Missouri's public institutions. In 2019 the Department of Higher Education was restructured to bring together workforce development and economic research to form a new department.

The State system of higher education serves more than 620,600 students attending Title IV post-secondary institutions in the State of Missouri. There are 13 public four-year universities, 14 public two-year colleges, 24 independent colleges, 11 specialized/technical colleges, 17 theological institutions and more than 150 proprietary and private career schools. The MDHE convenes meetings of the Higher Education Subcommittee of the Homeland Security Advisory Council approximately five times per year as a pre-disaster initiative. The role of this group is to promote pre and post disaster emergency planning initiatives on all higher education campuses in Missouri, share best practices, and ensure that collegiate institutions throughout the State are informed about and engaged in emergency planning. To this end, the Higher Education Subcommittee maintains a list of campus liaisons for coordination of statewide emergency and homeland security operations. All public and independent Missouri institutions of higher education are members of the Missouri Alert Network, which ensures that each campus will receive a message from state officials within a few minutes if an extraordinary situation occurs impacting security and safety. The Higher Education Subcommittee is also working with

institutions in reviewing and adapting the Emergency Response Information Program (ERIP) web-based tool to develop campus emergency response and all-hazard plans. Institutions can also provide tactical response information to community first responders using the ERIP system.

The Department of Higher Education did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Insurance

The Department of Insurance has resources for insurance customers, companies, and producers. The department is capable to promote flood and earthquake insurance as a pre-mitigation measure.

Mitigation-related Programs and Initiatives

RSMo 379.975

The Department enforces *RSMo 379.975,* which requires insurers to provide information to applicants and policyholders about earthquake insurance for properties located in the New Madrid Seismic Zone (that is susceptible to Modified Mercalli intensity VII or above earthquake), and *RSMo 379.978,* which requires all insurance companies that provide earthquake coverage to prepare a written disaster plan that addresses earthquakes.

Section 207 of the Flood Insurance Reform Act of 2004

Section 207 of the Flood Insurance Reform Act of 2004 requires all producers selling policies under the NFIP to be properly trained and educated about the NFIP to ensure that clients are better served. The federal law directs the Department of Insurance to require producers to complete a one-time NFIP course which provides continuing education credit to those insurance agents. Additionally, this department suggests that insurance producers advise their clients of the availability of flood insurance coverage.

Department of Labor and Industrial Relations

The Department of Labor and Industrial Relations is responsible for administering programs that provide payment of unemployment insurance benefits to workers who become unemployed through no fault of their own.

When a Missouri county or region is impacted by a natural disaster or hazardous condition such as flooding or inclement weather, the Labor Department has the authority to suspend in-person reporting required of the unemployed for a period of time. This helps to assist in the post-disaster recovery of the local communities. The Labor Department is capable with the support of other state and/or other government agencies, of providing fairly prompt unemployment insurance benefits to workers in disaster-affected areas.

The Department of Labor and Industrial Relations did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Mental Health

The Department of Mental Health (DMH) maintains an All-Hazard Emergency Operations Plan as a pre-disaster measure. The plan, developed with the input of the Mental Health Statewide Disaster Response Planning Committee, is designed to enhance department planning and response activities and minimizes the effects of disasters (natural, manmade or other) on DMH consumers and the residents of Missouri.

The Department also ensures the DMH facilities maintain and exercise facility emergency operations plans; provide education and training for people with special needs, schools, healthcare workers, and other first responders to mitigate the emotional impacts of disaster events; and maintains a Continuity of Operations Plan and a Pandemic Flu annex to help mitigate against the effects of displacement.

Mitigation-related Programs and Initiatives

The Office of Disaster Services

The Office of Disaster Services (ODS) plans and develops activities to support a coordinated mental health response for Missourians in disaster situations. ODS offers preparedness training in disaster mental health such as psychological first aid to health and mental health care providers, school personnel, community-based volunteer organizations, emergency responders, law enforcement personnel, mental health consumers, and the faith-based community. It also develops fact sheets about the emotional impact of disasters on different populations and common reactions to disaster.

ODS coordinates efforts with other agencies like Homeland Security, SEMA, and DHSS. Funding for ODS is currently through a partnership with DHSS using Federal Assistant Secretary for Preparedness and Response (ASPR) funding. This provides the behavioral health components needed in comprehensive planning. ODS also develops and administers the FEMA Crisis Counseling Program grant when a federal declaration for a disaster in Missouri.

Disaster Distress Helpline

People can call or text to get help and support for any distress they may be feeling related to any disaster. Call or text: 1-800-985-5990

Mental Health Disaster Training Opportunities

The Department of Mental Health website provides information about training opportunities provided by the Office of Disaster Services. The Office of Disaster Services conducts trainings as well as provides information on various trainings for different audiences and all Missourians, such as First Responders, educators, parents, children, etc. The training information on the website can help individuals find the right tools to help through the disaster recovery process; learning about emotions and what causes certain feelings to arise, plus gaining skills to manage and cope with post-disaster stress and adversity.

Access guidebooks, trainings and courses here: https://dmh.mo.gov/disaster-services/training-opportunities

Mitigation-related Plans and Reports

All-Hazards Emergency Operations Plan

This plan was developed with the input from the Mental Health Statewide Disaster Response Planning Committee. It was designed to enhance department planning and response activities in order to minimize the efforts of disaster or terrorism on DMH clients, the communities and the citizens of Missouri. The plan was revised in March 2011.

Mental Health Disaster Communication Guidebooks

The Department of Mental Health partnered with DHSS to develop a public education program on emotional preparedness for any event Missourians may face that included talking points to help promote emotional well-being and greater coping skills for those facing the negative effects of a disaster. https://dmh.mo.gov/media/pdf/disaster-communications-guidebook-preparedness-public-education-response-and-recovery

Missouri Department of Natural Resources

The Missouri Department of Natural Resources (MoDNR) protects Missouri's air, land and water; preserves our unique natural and historical place; and provides recreational and learning opportunities for everyone. MoDNR includes the Division of Environmental Quality, the Missouri Geological Survey and Missouri State Parks. The department administers various projects designed to reduce stream bank erosion, reduce localized flooding, improve drainage, reduce discharge, improve water quality, ensure safe drinking water, and make sure that dams are constructed, maintained, and operated in a safe manner.

The Missouri Geological Survey (MGS) includes the Geological Survey Program, the Land Reclamation Program, the Water Resources Center, the Soil and Water Conservation Program, and the Dam and Reservoir Safety Program. MGS has many multi-disciplined geoscientists, engineers and technical professionals to assist in providing professional and technical advice to state and local emergency managers and other officials. Most of MGS's professional and technical staff hold certifications in various emergency response functions and can provide technical assistance, education, and guidance in the use and protection of Missouri's natural resources, as well as interpret the state's geological settings, resource potential and geological hazards.

The State Historic Preservation Office (SHPO) is in the department's Division of State Parks. The SHPO, in coordination with SEMA, performs historic preservation reviews of proposed FEMA-funded mitigation projects.

MoDNR's Division of Environmental Quality also has an Environmental Emergency Response (EER) section under the Environmental Services Program. This section responds to natural disasters to assist in providing potable water, restoring basic services such as water and wastewater, managing environmental clean-ups, etc. The EER section also has a 24-hour call response line, and provide staff to man the State Emergency Operations Center (SEOC) in times of emergency.

Mitigation-related Programs and Initiatives

Dam and Reservoir Safety Program

The Missouri Dam and Safety Reservoir Law of 1979 establishes a dam safety program in the Missouri Department of Natural Resources to ensure that dams in the state are constructed, maintained, and operated in a safe manner. This is accomplished by regulation of all nonagricultural, nonfederal dams of more than 35 feet in height and by providing technical assistance and informational resources to all dam owners. The law also establishes the Dam and Reservoir Safety Council, whose responsibilities are to adopt and amend technological guidelines, standard guidelines, rules, and regulations applicable to the permits, design, construction, maintenance operation, alteration, repair, reduction, removal, and natural physical changes that may occur to a dam or reservoir. The Dam and Reservoir Safety Program is leading an effort to develop Emergency Action Plans (EAPs) for regulated dams that will help save lives and reduce property damage during a dam safety emergency. EAPs increase preparedness by organizing emergency contact information and evacuation procedures into an official document, and by providing enhanced communications between dam owners and local emergency managers. The Program coordinates with SEMA when a problem develops with a dam. If this problem occurs after hours or on a weekend, SEMA's duty officer is notified. The SEMA duty officer responds as appropriate to the situation's needs, according to a manual of procedures.

Geological Survey Program's Earthquake Response Plan and Hazards Mapping

The Geological Survey Program (GSP) developed and maintains an Earthquake Response Plan which provides the post-earthquake geologic investigations procedures that will be undertaken by MGS staff in response to a significant earthquake within the state, or damage within the state caused by earthquakes located outside the state. This plan defines the criteria for initiation of an earthquake response and outlines the response objectives and subsequent plans of action. It also discusses the organization of the Post-Earthquake Technical Information Clearinghouse (PETIC) that will serve as a control for gathering and dissemination of scientific information and credentialed geoscientists and engineers into and out of the affected area. GSP created geologic hazards and debris management maps to assist emergency managers and first responders in their planning and response to a disaster. The geologic hazards maps highlight areas of the state prone to landslides, liquefaction and collapse due to karst or underground mines. The debris management maps provide site suitability, based on geologic and hydrologic conditions, for the disposal of waste and demolition debris following a major disaster. Geologic hazards maps are available state-wide. To date, debris management maps are available in the Poplar Bluff, Cape Girardeau, Farmington and St. Louis, Missouri areas.

GSP is actively pursuing and participating in education and outreach opportunities throughout the state targeting earthquake awareness and environmental stewardship. GSP participates in Earthquake Awareness Month conducting workshops and seminars with SEMA, the Central United States Earthquake Consortium (CUSEC), the Missouri Seismic Safety Commission (MSSC) and other public and private institutions to promote earthquake mitigation and education.

Stormwater Improvements Program

In 2001, the Missouri Department of Natural Resources awarded more than $9.9 million to 46 Missouri communities for stormwater improvements. Of these 46 communities, seven had populations of 3,000 or less. Funding for these grants came from bond issues approved by Missouri voters in 1998 for improvements to stormwater, wastewater treatment, and public drinking water systems. The last bond sale occurred in 2002. The types of projects approved included developing city and county stormwater management plans, replacing undersized drainage systems, buying and demolishing flood-prone homes, and implementing structural measures to alleviate erosion and prevent future channel degradation.

Mitigation-related Plans and Reports

MoDNR Missouri Drought Plan

The Missouri Drought Plan, 2002, addresses the need for coordinated response and advanced emergency planning. It complements and supports the State Consolidated Plan and the State Emergency Operations Plan. The Drought Plan outlines proactive strategic and tactical measures designed to better prepare Missouri for drought.

Drought Response, Recovery and Resilience: A Guide for Public Water Systems

The Water Protection Program, a subgroup under the Division of Environmental Quality, created a fact sheet that describes common issues that arise from periods of extended drought and provides guidance on how public water systems can prepare for, respond to, and recover from severe drought. This document also provides a summary of strategies and practices that public water systems may consider developing additional resilience to future episodes of drought.

2018 Drought Response Report

Missouri's drought of 2018 was notable in its localized intensities and its overall impacts to both agriculture and public water supplies. Ninety-eight percent of the state experienced dry to exceptional

drought conditions at the peak of the 2018 Drought. A drought assessment committee was created to develop this report which includes a progression of drought response actions and how to prepare for remaining or future droughts.

Missouri Water Supply Study, Amended 2013

The department's Water Resources Center and the Safe Drinking Water Program are responsible for assisting state residences in assuring an adequate and safe water supply. The purpose of a water supply study is to ensure availability of water information for effective decision-making by communities and department managers. In addition, studies are expected to be used to determine and allocate existing water supplies. The scope primarily addresses surface water supplies for cities and communities that are expected to experience water shortages during an extended drought. Surface water supplies consist of lakes and rivers and streams, and in many cases combinations of both.

Missouri Water Resources Plan

The Missouri Department of Natural Resources determined through previous water planning that water demands in certain areas of the state cannot be met long term, especially under drought conditions. The Missouri Water Resources Plan will help to identify future shortfalls in water supplies and explore options to address those water needs. This may include project recommendations such as new infrastructure development, regionalization of water use, integrating water supplies and pursuing financial assistance opportunities.

Department of Public Safety

The Department of Public Safety is comprised of the Office of Homeland Security, and the divisions of the Missouri State Highway Patrol (combined with Water Patrol since the 2013 plan), State Emergency Management Agency, Missouri National Guard-Office of the Adjutant General, Division of Fire Safety, Capitol Police, Division of Alcohol and Tobacco Control, Missouri Veterans Commission, and Missouri Gaming Commission.

The Department's desired outcomes that are specific to mitigation efforts are: to mitigate the threat of terrorism; reduce preventable injuries and fatalities; interoperable communications for law enforcement and emergency services; increase crime prevention; and to improve the ability to respond and provide recovery from all "hazard events".

The Department of Public Safety did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Fire Safety

The Division of Fire Safety and the State Fire Marshal provide fire and life safety enforcement and education to all residents so they receive the highest quality of service to ensure safety and a sense of wellbeing. The State Fire Marshal provides post disaster assistance to local jurisdictions through Incident Support Teams and this initiative provides experienced command level personnel to assist in local Emergency Operation Centers (EOC).

Mitigation-related Programs and Initiatives

Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE), dated 2022

Started as a grant from the International Association of Fire Chiefs (IAFC) to the Missouri Association of Fire Chiefs (MoChiefs) to review and revise Missouri's Fire Mutual Aid program and produce a mutual

aid template capable of being used by any responder discipline. This revision was completed in 2022 and was called MoSCOPE (Missouri Systems Concept of Operational Planning for Emergencies). The purpose of MoSCOPE is to coordinate and support the identification, deployment, transportation and demobilization of resources utilized during large scale events and expanding incidents when additional resources are needed. Specifically, this document will provide a platform for sharing and receiving resources, locally, regionally, and nationally.

Office of Homeland Security

In Missouri, the Office of Homeland Security is within the Department of Public Safety, and coordinates between other Department of Public Safety agencies and between SEMA and the State Highway Patrol. "Homeland security" covers all of the public safety missions ranging from law enforcement, fire service, and first-responders, to emergency preparation, management, training and mitigation.

The Homeland Security Advisory Council (HSAC) was authorized to review state and local security plans and grant funding requests and make recommendations for changes to better protect Missourians by Executive Order on July 21, 2005. The HSAC was designed to include the Director of the Department of Public Safety and relevant Public Safety Division Directors, and equally important directors of other state departments. This ensures a statewide focus for homeland security and an effective means for coordinating resources.

On February 10, 2006, Executive Order 06-09 was issued making the HSAC a permanent governing body. The Executive Order created the position of Homeland Security Coordinator, under the direction of the Director of the Department of Public Safety. The order also added the Director of the Department of Mental Health to the HSAC, and facilitated the formation of the Regional Homeland Security Oversight Committees (RHSOCs) to give local input from all areas of Missouri to the HSAC. Virtually all of the federal homeland security grant money allocated to Missouri has been committed, and most of it already spent on vital homeland security programs and initiatives. To date, Missouri has not turned any money awarded back to the federal government.

The HSAC has been tasked with ensuring that homeland security plans and coordination are in place at the state and local level and that homeland security grant expenditures are done in a coordinated and efficient way.

State Highway Patrol

The Missouri State Highway Patrol enforces traffic laws and promotes safety on the highways. The State Highway Patrol provides all officers with training on weapons of mass destruction and gives additional terrorism training to sergeants and staff officers. They establish and maintain communications with all local police and sheriff departments, particular during and after natural disaster events. There are also four special emergency response teams located throughout the State that are available to assist at all times.

Mitigation-related Programs and Initiatives

Missouri Homeland Security Alert Network

Provides Missouri public safety officials with immediate phone, email and text message broadcast capabilities to the key individuals within each participating stakeholder community. By utilizing this network, public safety, health, and other officials will be able to instantly message up to 5,000 elected and appointed leaders in individual first responder and other stakeholder communities such as police, sheriff’s, fire departments, county and city government, emergency medical services (EMS), 9-1-1

Centers, and even key private sector stakeholders. The system allows a message to be sent to just one discipline or community of stakeholders, or to everyone. A message can also be sent to a selected geographic area, or the whole state.

Department of Social Services

The Department of Social Services (DSS) is the lead state agency responsible for coordinating mass care activities during disaster events. Mass care activities primarily include coordination of sheltering for general populations, and food, water and bulk distribution coordination in affected areas in partnership with the American Red Cross, the Salvation Army, other non-governmental or volunteer organizations and other state agencies. DSS employees respond to the State Emergency Operations Center to staff the Emergency Support Function 6 (ESF 6) desk during disaster events. DSS employees have also been assigned to respond to the two State Area Coordination Centers as needed. DSS County Managers participate in local emergency planning activities. They immediately contact their local Emergency Management Directors during an emergency event and provide assistance if needed. On-going training is provided to all staffing levels to prepare for mass care responsibilities. Field staff provide daily reporting of local emergency management activities, i.e., shelter operations status, shelter locations, number of residents, special requests, etc. Field staff participate in Multi Agency Resource Centers following disaster events. DSS participates in exercises and exercise planning with SEMA and other state and federal agencies as well as other partners in an effort to be as prepared as possible to respond adequately and appropriately when a disaster event occurs.

Mitigation-related Programs and Initiatives

Emergency Operations Plan, Children's Division, updated 2015

Designed to help DSS, Children's Division respond in all four phases of emergency management by providing all services needed by the children and families they serve.

Department of Transportation

The Department of Transportation (MoDOT) is a key responder in most emergencies and disasters in the State of Missouri. The primary MoDOT mission as it relates to emergencies and disasters is to "get the roads open." During a response effort, MoDOT uses all of its resources including thousands of field staff and related equipment, administrative personnel and other personnel to manage emergency events and works in coordination with other emergency response agencies. MoDOT maintains a Traveler Information Map at http://traveler.modot.org/map/http://www.modot.org/ that provides real time information on road conditions, incidents and work zones. MoDOT also has traffic management systems in place that manage all of the urban and rural interstate highways and some other routes. These systems include 24/7 Traffic Management Centers in St. Louis and Kansas City, 24/7 emergency response crews around the State and field devices such as video cameras electronic message signs, weather stations and traffic detectors. MoDOT also provides a key coordination role with general aviation airports, public transit, waterway ports and railroads. MoDOT personnel provide technical assistance to various emergency management programs, including mitigation. In addition, MoDOT incorporates flood and earthquake standards into new bridge designs and is working on a database that identifies which Missouri bridges have been constructed or retrofitted to earthquake design standards. MoDOT also works on major river bridge projects and wetland reestablishment and rehabilitation. The agency also enforces hazardous materials regulations and manages the registration and licensing of carriers who haul hazardous waste through the State. HazMat response coordinators from the 7 districts work with the MoDNR on spill response.

Mitigation-related Programs and Initiatives

Statewide Transportation Improvement Program

Identifies all transportation projects planned by state and regional planning agencies. The program includes projects for highways, bridges, transit, aviation, rail, waterways, and other projects. It is a project-specific document that tells Missourians what improvements to expect on their transportation system. Projects must consider mitigation against hazards, specifically relating to flooding and earthquakes. This five-year plan is updated each year, and as one year of work is completed, a fifth year of new projects is added.

Wetland Mitigation

Since the beginning of the U.S. Army Corps of Engineers (COE) Section 404 regulatory permitting process, MoDOT has constructed or has been responsible for constructing approximately 69 mitigation sites composed of over 600 acres (excluding mitigation bank sites). These sites are distributed statewide, and many times are located within MoDOT right-of-way (ROW) or immediately adjacent to ROW. MoDOT must monitor these sites for at least five years following their completion to ensure their success. The ultimate intent is to relinquish these properties to a trust or non-profit organization so that they can perform any long-term maintenance and protection.

Office of Administration

The Office of Administration enforces floodplain management regulations for state facilities. The Office of Administration's Division of Design and Construction manages the State's facilities program. It selects consulting architectural and engineering firms for capital improvements projects, administers the construction program, and assists agencies in preparing their capital improvement budget requests.

The Office of Administration did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Public Service Commission

The Missouri Public Service Commission (PSC) regulates investor-owned public utilities operating in Missouri that can be affected by disaster events. The PSC has the statutory responsibility for ensuring that customers receive adequate amounts of safely delivered and reasonably priced utility services at rates that will provide the companies' shareholders with the opportunity to earn a reasonable return on their investments. The PSC must balance a variety of often competing private interests to ensure the overall public interest.

The Public Service Commission did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

4.5.2. Policies and Regulations

The State has several statutes that address hazard mitigation through the creation of special councils or committees and rules and requirements for agencies and local governments to follow. These primarily address seismic hazards, floodplain management, water resources, dam and reservoir safety, as well as public health emergencies. **Table 4.14** summarizes the statutes and executive orders that enhance the State's capabilities to reduce the impacts of future disasters.

Table 4.14. Missouri State Statutes and Executive Orders

Policy	Requirements
RSMo 44.020: State Emergency Management Agency created	There is hereby created within the department of public safety, the "State Emergency Management Agency," for the general purpose of assisting in coordination of national, state, and local activities related to emergency functions by coordinating response, recovery, planning and mitigation. This agency shall also serve as the statewide coordinator for activities associated with the National Flood Insurance Program.
RSMo 44.028: State may accept federal goods and services on behalf of itself and its subdivisions	Whenever the federal government or officer or agency thereof shall offer to the State, or through the State to any political subdivision thereof, services, equipment, supplies, materials or funds by way of gift, grant or loan, for the purpose of emergency management, the State acting through the agency, or the political subdivision, through its executive officer with the consent of the governor, may accept the offer and may receive these services, equipment, supplies, materials or funds on behalf of the State or the political subdivision subject to the terms of the offer.
RSMo 44.080: All political subdivisions shall establish a local emergency management	Each political subdivision of this state shall establish a local organization for disaster planning in accordance with the state emergency operations plan and program. The executive officer of the political subdivision shall appoint a coordinator who shall have direct responsibility for the organization, administration and operation of the local emergency management operations, subject to the direction and control of the executive officer or governing body. Each local organization for emergency management shall be responsible for the performance of emergency management functions within the territorial limits of its political subdivision, and may conduct these functions outside of the territorial limits as may be required pursuant to the provisions of this law.
RSMo 49.600: National flood insurance program, adoption and rescission procedure-exemptions (certain second-, third-fourth-class counties)	The county commission, in all counties which have not adopted county planning and zoning, may adopt or rescind by order or ordinance regulations to require compliance with FEMA standards, necessary to comply with the National Flood Insurance Program, in any flood hazard area designated by FEMA; provided, however, that no ordinance or order enacted pursuant to this section in any county shall be effective unless the county commission or governing body of the county submits to the voters of a county a proposal to authorize the county commission or governing body of the county to adopt such an order or ordinance.
RSMo 49.605:Permits, authorized requirements for applicant	No permit required by the provisions of order or ordinance regulations adopted pursuant to the provisions of sections 49.600 to 49.615 shall be denied an applicant if the proposed construction, use or other development will not raise the flood elevation of the 100-year flood level more than one foot; provided, however, that any permit may require that the lowest floor of an insurable structure shall be above the 100-year flood level and that all structures shall be adequately anchored to prevent flotation, collapse, or lateral movement of the structure.
RSMo 700.015: Code compliance required, when — seal required — exemptions from code requirements for sale of new recreational vehicles and park trailers	No person shall rent, lease, sell, or offer for sale any new manufactured home manufactured after January 1, 1974, unless such manufactured home complies with the code and bears the proper seal. No person shall manufacture in this state any manufactured home or modular unit for rent, lease or sale within the State which does not bear a seal evidencing compliance with the code. No person shall offer for rent, lease or sale a new modular unit or a unit used for educational purposes manufactured after January 1, 1974, unless such modular unit complies with the code and bears a seal issued by the commission evidencing compliance with the code.

Policy	Requirements
RSMo 700.065: Manufactured homes to be anchored	All manufactured homes located in this state shall be anchored and tied down in accordance with the standards promulgated by the commission pursuant to the provisions of sections 700.010 to 700.115 and 700.650 to 700.692.
RSMo 44.227-237:Commission on seismic safety created	Authorizes creation, duties, and powers of the Missouri Seismic Safety Commission, as well as gives the commission responsibilities to undertake a study to determine the feasibility of establishing a comprehensive program of earthquake hazard reduction to save lives and mitigate damage to property in Missouri.
RSMo 160.451:Earthquake emergency system to be established for certain school districts	The governing body of each school district which can be expected to experience an intensity of ground shaking equivalent to a Modified Mercalli of VII or above from an earthquake occurring along the New Madrid Fault with a potential magnitude of 7.6 on the Richter Scale shall establish an earthquake emergency procedure system in every school building under its jurisdiction. The governing body of each school district shall request assistance from the state emergency management agency and any local emergency management agency located within its district boundaries to develop and establish the earthquake emergency procedure system.
RSMo 160.453: Requirements for emergency system—public inspection of system authorized	This earthquake emergency system shall include 1) A school building disaster plan; 2) An emergency exercise to be held at least twice each school year; 3) Protective measures to be taken before, during, and following an earthquake; and 4) A program to ensure that the students and certified and noncertified employees of the school district are aware of, and properly trained in, the earthquake emergency procedure system. Additionally, Each school district shall make available for public inspection during normal business hours its earthquake emergency procedure system.
RSMo 160.455: Distribution to each student certain materials on earthquake safety—duties of school district	At the beginning of each school year, each school district shall distribute to each student materials that have been prepared by the Federal Emergency Management Agency, SEMA, or by agencies that are authorities in the area of earthquake safety and that provide the following objectives: 1) Developing public awareness regarding the causes of earthquakes, the forces and effects of earthquakes, and the need for school and community action in coping with earthquake hazards; 2) Promoting understanding of the impact of earthquakes on natural features and manmade structures; and 3) Explaining what safety measures should be taken by individuals and households prior to, during and following an earthquake.
RSMo 256.173: Cities and counties to be furnished geologic hazard assessment prepared by Missouri Geological Survey	The Missouri Geological Survey in the Missouri Department of Natural Resources shall provide each county as the information becomes available a geologic hazard assessment and assistance in the use and application of the geologic hazard assessments, which will be made available to the public. The Department of Natural Resources shall provide each recorder of deeds of each county in the State a map showing the downstream area that would be affected in the event of a dam failure.
RSMo 256.175: High seismic risk area data-duties of department	The Missouri Department of Natural Resources shall furnish to SEMA technical data, including soil liquefaction and seismic effects, on structural foundations that are located in a high seismic risk area. If requested by a local government entity, the department shall assist in the establishment of construction standards based on the data provided in this subsection. The Department shall be designated as the lead technical agency in the State to conduct studies concerning the geologic effects of earthquakes.

Policy	Requirements
RSMo 319.200-207: Notice to cities and counties subject to earthquake to adopt seismic construction and renovation ordinances, when-standards	Each city, town, village, or county that can be expected to experience an intensity of ground shaking equivalent to a Modified Mercalli of VII or above from an earthquake occurring along the New Madrid Fault with a potential magnitude of 7.6 on the Richter, shall adopt an ordinance or order requiring that new construction, additions and alterations, comply with the standards for seismic design and construction of the building officials and code administrators code or of the uniform building code.
RSMo 379.978: Written disaster plan, insurer to develop, contents	Every insurance company that insures property for loss caused by earthquake shall prepare and retain a written disaster plan covering earthquakes. This plan shall include specific provisions regarding procedures for handling claims under the insurance company's issued policies or endorsements covering loss or damage from the peril of earthquake.
RSMo 640.412: Inventory to be maintained on ground and surface water uses, quantity, and users	The Department of Natural Resources shall inventory 1) existing surface water and groundwater uses; 2) the quantity of surface water and groundwater available for uses in the future; and 3) water extraction and use patterns, including regulated and unregulated users.
RSMo 640.415: State water resource plan to be established for use of surface and ground water—annual report, contents—powers of department	Authorizes the Department of Natural Resources to develop, maintain, and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the State, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection, and related needs. This plan shall be known as the "State Water resources Plan". The department shall collect data, make surveys, investigations and recommendations concerning the water resources of the State as related to its social, economic and environmental needs.
RSMo 644.018: Reasonable use defined in cases involving surface water in flood-prone areas	In any contested case or judicial proceeding filed after January 1, 1998, involving surface water in any flood-prone area, if any defendant has obtained and fully complied with a permit from a political subdivision which has enacted orders or ordinances as required by FEMA as a prerequisite to participation in the National Flood Insurance Program, and which political subdivision has jurisdiction, pursuant to the zoning laws of this state or the laws and regulations of FEMA, over the area in dispute, then the proper permitting and compliance with all conditions of such permitting of such project shall be conclusive proof that the project is a reasonable use and meets any reasonable-use test imposed by law or by a court.
RSMo 245.015: Owners may form levee district, where—articles of incorporation to be filed in circuit court	The owners of a majority of the acreage in any contiguous body of swamp, wet or overflowed land or other property in the nature of individual or corporate franchises in this state, or land subject to overflow, wash or bank erosion, located in one or more counties or in any city, town, or village in this state not located within any county with a charter form of government and with more than two hundred fifty thousand but less than three hundred fifty thousand inhabitants, or in any city, town, or village of the third or fourth classification in this state which is located within any county with a charter form of government and with more than two hundred fifty thousand but less than three hundred fifty thousand inhabitants, may form a levee district for the purpose of having such land and other property reclaimed and protected from the effects of overflow and other water, for sanitary or agricultural purposes, or from the effect of wash or bank erosion, or when the same may be conducive to the public health, convenience or welfare, or of public utility or benefit, by levee, or otherwise.

Policy	Requirements
RSMo 254.270. Fire control and timber trespass activities intensified, when—provisions for added protection	Fire control and timber trespass activities will be intensified and may be extended to include all woodlands in the State as deemed in need of such protection by the commission within the limits of funds provided. Any person whether or not his lands are classified as forest croplands may receive such assistance. Any owner may make application to the commission for special attention in forest fire control requiring expenditures in excess of those permitted within the limits of funds provided for general activities under this chapter, by subscribing a payment of not less than three cents per acre per year for such added protection as the commission may deem advisable and desirable.
RSMo 640.130: Emergencies—actions to be taken—water systems in violation, penalties	Whenever the Department of Natural Resources determines that an emergency exists which endangers or could be expected to endanger the public health and safety with regard to drinking water supplies, the department may, without notice or hearing, issue an order reciting the existence of such a condition and requiring the person to take such action as will lessen or abate the danger. At the request of the department, the attorney general may bring an injunctive action or other appropriate action in the name of the people of the State Whenever the department determines that a public water system is in violation ... it may issue an administrative order requiring the public water system to comply with such rule or statute.
RSMo 640.140: Department may cooperate with others—may receive aid, conduct training and research—may financially assist in construction of water systems	The Department of Natural Resources may enter into agreements, contracts, or cooperative arrangements under appropriate terms and conditions with other state agencies, federal agencies, interstate agencies, political subdivisions, educational institutions, local health departments, or other organizations or individuals for the purpose of administering the State drinking water supply program. The department may solicit and receive grants of money or other aid from federal and other public or private agencies or individuals ... to conduct research and training activities or cause them to be conducted, to financially assist in the construction of water works systems or portions thereof, or for other program purposes.
RSMo 319-500: Pipelines transporting hazardous liquids to submit periodic reports to department of natural resources—content	Any owner or operator of pipelines transporting hazardous liquids, as defined in the federal Hazardous Liquid Pipeline Safety Act of 1979, 49 USC 2001, et seq., shall submit periodic reports to the department of natural resources as required by the director of the department of natural resources under this section.
RSMo 44.090: Repealed in 2009 & new section enacted for Missouri's mutual aid system	The Missouri mutual aid system shall be administered by the department of public safety, which may authorize any organization to assist in the administration of the mutual aid system.
19 CRS 20-20.020	Missouri disease reporting requirement to DHSS
Executive Order 93-40, 1993	Establishes the Task Force on Flood Plain Management and the composition of its members. The task force reviews and makes recommendations on 1) the building, rebuilding, or relocation of levees; 2) state highway and road projects in floodplains; and 3) expenditures of public funds for projects in floodplains which require state action or approval. The task force will make recommendations to the governor regarding proposed legislation and long-term policy regarding development of housing and other private and public structures in floodplain areas.
Executive Order 94-25, 1994	Establishes the Disaster Recovery Partnership to review and design new human services disaster response and recovery delivery methods, establish more rapid and complete communications to disaster victims and caregivers, and promote, train, and support local committees.

Policy	Requirements
Executive Order 98-3, 1998 (revised Executive Order 97-09, 1997).	Authorizes SEMA to issue floodplain development permits for any state owned or leased development in a special flood hazard area.
Executive Order 03-23, 2003	Reaffirms the endeavors of the Disaster Recovery Partnership and ascribes to it the additional functions of a state citizen council.
Executive Order 05-20, 2005	Establishes the Missouri Homeland Security Advisory Council to review and evaluate current state and local homeland security plans and make recommendations for changes to better protect Missourians and to review requests and provide recommendations on the appropriate use of Homeland Security grant funds from the federal government. Creates the Division of Homeland Security within the Department of Public Safety to coordinate activities to promote unity of effort among federal, state, local, private sector, and citizen activities related to emergency preparedness and homeland security.
Executive Order 06-10, 2006	Creates the Citizen Corps to help coordinate volunteer and individual or family preparedness activities in any emergency situation
Executive Order 06-41, 2006	Creates the Interdepartmental Coordination Council for Water Quality
Executive Order 09-25, 2009	Creates and establishes the Governor's Faith-Based and Community Service Partnership for Disaster Recovery. It is comprised of governmental and private agency representatives.

4.5.3. Development in Hazard-Prone Areas

Missouri is a "home-rule" state and does not have a statewide program for land use or a statewide building code; however, the State does address development in seismic and flood hazard areas. State statutes require that new public construction, additions, and alterations comply with certain standards for seismic design and construction if located in areas subject to a certain level of ground shaking. It is up to local governments to implement and enforce the use of building codes. SEMA emphasizes the use of building codes at mitigation training programs and when briefing new state legislators.

As a result of a 1998 Executive Order, SEMA issues floodplain development permits for any state-owned or leased development in a Special Flood Hazard Area. Local governments participating in the NFIP address development in flood hazard areas through their floodplain management ordinances.

4.5.4. State Funding Capability

The majority of funding for hazard mitigation projects in Missouri is attained through federal programs. More information on these funding sources is provided in **Section 4.5.1** State Agency Capability Assessment under the Mitigation-Related Funding Sources Heading for each agency and **Section 4.4**, Funding Sources. The mitigation-related funding from the state budget includes partial funding of the floodplain management budget. For Fiscal Year 2023, the State General Revenue contribution for floodplain management includes:

- $27M - Columbia Bottom Levee Setback and Road Relocation - Reconnecting the Missouri and Mississippi Rivers with the historic floodplain in St. Louis County and securing more than three thousand acres of forested wetland for additional flood storage in the Columbia Bottom Conservation Area. The project will also relocate the damaged main road away from flood hazards and add flood resiliency features to maintain a popular river access in the area.

- $10.5M - Missouri Hydrology Information Center - Establishing a new Missouri Hydrology Information Center that will focus on flood-related projects, drought mitigation, aquifer characterization, modeling, and prediction. The center was recommended by the Governor's Flood Recovery Advisory Working Group to help Missourians understand their flood risk, drought susceptibility, water supply, and be better prepared for extreme weather events including flooding and drought.
- 1.8M – Flood Control Land Grants - The Flood Control Lands Grant is a pass-through of funds that represents 75 percent of the monies from leases of the land owned by the United States under the Flood Control Act. Sections 12.080 and 12.090, RSMo, prescribe that the funds be used for the benefit of public schools and public roads of the county in which the government land is situated. These funds may also be used for any expenses of the county government, including public obligations of levee and drainage districts for flood control and drainage improvements.
- $328,125 for the Lower Missouri River Flood Risk and Resiliency Feasibility Study.
- $190,009 for the Clarence Cannon Dam water contract.
- $134,196 for geologic mapping to locate critical mineral reserves.
- $55,405 federal funds for floodplain engineering and mapping.

Section 44.032 of the Missouri Revised Statutes establishes the Missouri Disaster Fund to "furnish immediate aid and relief." The fund is primarily for response and recovery costs, but the section states that "provisions of this section shall be liberally construed in order to accomplish the purposes of sections 44.010 to 44.130. Section 44.010 defines emergency management functions, emergency management activities, and emergency management service as "those functions required to prepare for and carry out actions to prevent, minimize and repair injury and damage due to disasters".

4.5.5. Changes and Challenges in Capabilities

As the Missouri State Hazard Mitigation Plan has evolved, the State's capabilities related to mitigation have also grown. The continued coordination and collaboration resulting from the regular meetings of the State Risk Management Team have provided a framework for regular discussion of pre- and post-disaster risk management and mitigation opportunities in Missouri. Additionally, SEMA's overall program has been strengthened by legislation (Missouri House Bill 579) that transferred SEMA from the Office of the Adjutant General to the Department of Public Safety. This allows for the deployment of workers and volunteers, such as healthcare providers, that are licensed, registered, or certified in Missouri or any other state during an emergency declared by the governor. Prior to the bill's passage, only workers and volunteers licensed, registered, or certified in Missouri could be deployed. This bill also granted volunteers immunity from civil damages for their services unless the damages are due too willful and wanton acts or omissions in rendering care.

An evaluation of pre- and post-disaster capabilities took place on a program level during the 2023 update. This program-level evaluation was based on increases in community participation in programs such as the NFIP and CRS, implementation of the Risk MAP program and successful use of pre- and post-disaster mitigation projects funds. A greater number of communities are participating in the NFIP, partnerships among federal and state agencies and local governments continue to grow, and new strategic planning efforts have been undertaken. These changes in programs, outreach and

partnerships, plans, policies and regulations are summarized below. The end of this section discusses opportunities to continue to enhance state capabilities related to mitigation.

National Flood Insurance Program and Community Rating System

As of May 2022, 681 communities in Missouri participate in the National Flood Insurance Program. Of these communities, 15 (or 2.2 percent) participate in the Community Rating System. Of the top 50 Missouri communities (in terms of flood insurance policies in force), 9 participate in the CRS. The remaining 41 communities in the top 50 present an outreach opportunity for encouraging participation the CRS.

Table 4.15 provides additional details on changes in NFIP participation from 2018 to May 2022.

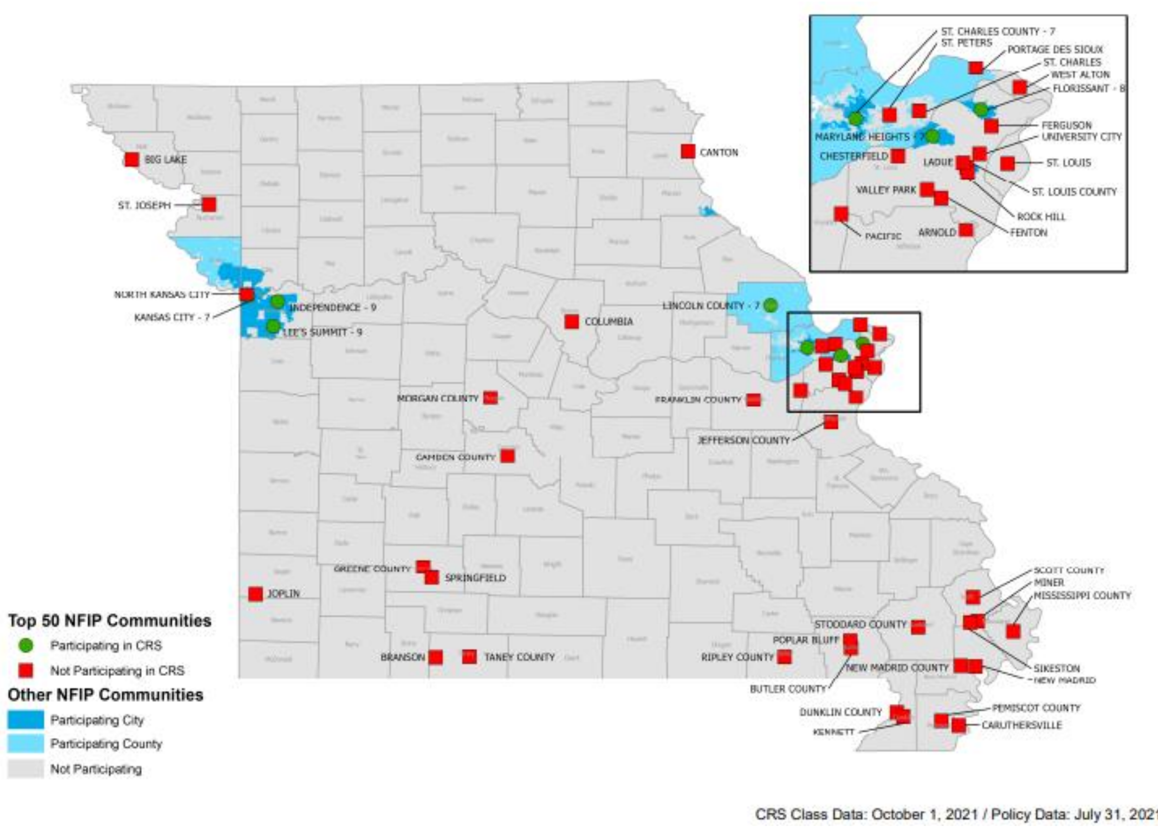
Table 4.15. Changes in NFIP Participation 2018 to 2022

NFIP Participation	May 2018	May 2022
Total in Regular Program	672	681
Total in Emergency Program	1	0
Total in NFIP	673	681
CRS Communities	10	15
Mapped Hazard Area, Not in Program	162	194
Total Suspended	6	6

Source: https://www.fema.gov/cis/MO.pdf

Figure 4.8 provides a statewide view of participation in the Community Rating System.

Figure 4.8. Participation in CRS in Missouri



Source: Missouri CRS Map - October 2021 (crsresources.org)

Challenges in implementation of the National Flood Insurance Program include:

- Lack of administrative capability in some small communities to effectively administer the NFIP.
- The current distinction of the 1-in-100-year flood zones for mandatory coverage may have led some consumers to believe erroneously that they do not have significant flood risk when they are not required to purchase flood insurance. It is politically and logistically infeasible to require mandatory flood insurance coverage for all property owners, or even to significantly expand the existing mandatory footprint. However, increasing consumers' awareness and educating them about their flood risk can potentially increase take-up in areas outside the mandatory coverage areas.
- Changing risk areas over time can pose a challenge in implementation of the NFIP.
- Changes in development as well as changing future conditions due to climate trends pose challenges with respect to creating a dynamic risk area.

Risk Mapping, Assessment, and Planning (Risk MAP) Program

The Missouri State Emergency Management Agency (SEMA) is responsible for the National Flood Insurance Program (NFIP) and floodplain management, protection, and planning in the State of Missouri. SEMA has worked closely with the Federal Emergency Management Agency (FEMA) on various activities associated with the National Flood Insurance Program (NFIP) and has been a Cooperating Technical Partner (CTP) since June 1999. SEMA is proud of the Federal/State partnership that has developed through the years with this program. As indicated by quarterly reports and scores from Region VII over the life of the partnership, SEMA's CTP Program are in excellent standing with FEMA and meets the requirements for continued programmatic funding.

Vision and Goals

The overarching intent of the program is to reduce the loss of life and property from flooding statewide through accurate risk assessments, community engagement, risk education and easily accessibly digital products.

FEMA's Technical Mapping Advisory Committee (TMAC) and FEMA have developed many recommendations for the updated NFIP program. SEMA has embraced these initiatives and strives to continue to be a valued partner with FEMA Region VII to meet and exceed national program goals and metrics. SEMA is prepared for the transition to Risk 2.0, Graduated Risk Analytics and structure specific risk.

FEMA's Risk MAP program has a couple major moonshot goals:

1. Double the number of structures covered by flood insurance through extended risk assessments and education. Nearly 25% of the flood insurance claims during the 2015 and 2017 disasters in Missouri were from locations outside the 1% floodplains. With the switch to 2D Rain on Grid modeling approach in 2018, SEMA is well equipped to communicate these areas of Pluvial Flooding Risk to stakeholders.
2. Increase the spending on mitigation by 400% to reduce and better manage the risk. SEMA has and continues a progressive approach to "investing" in mitigation to improve resilience and reduce project life costs.

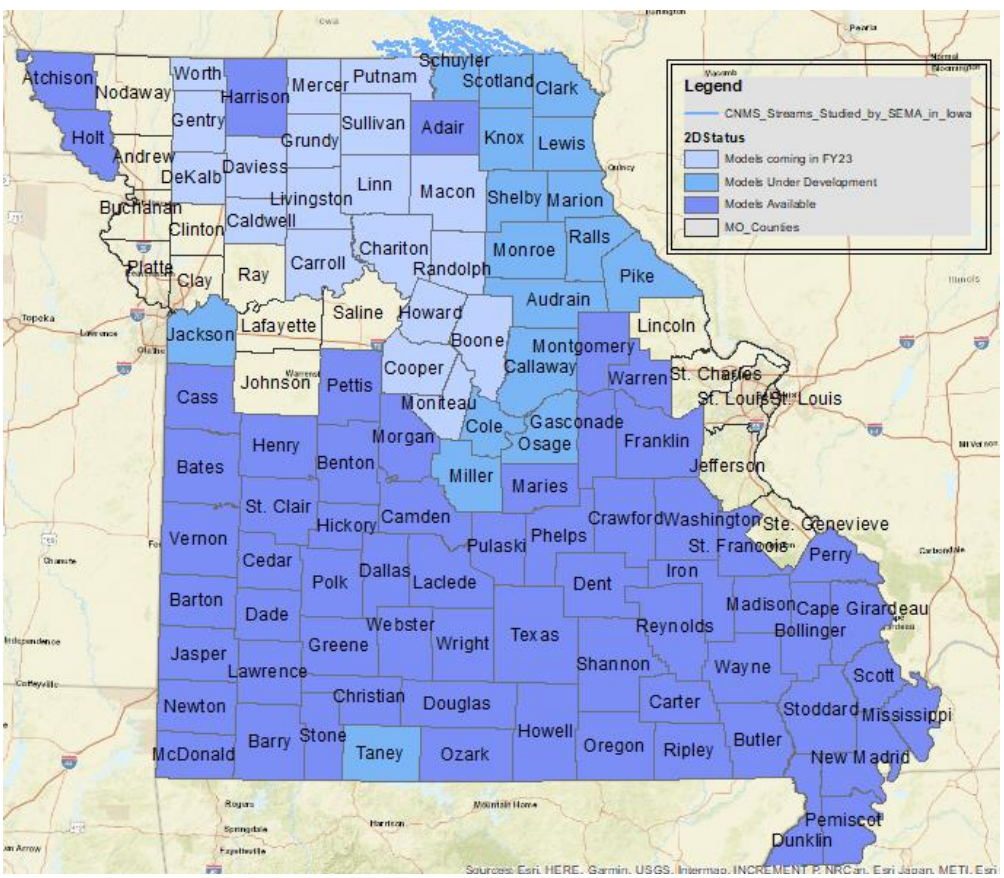
In support of this vision, SEMA was among the first in the nation in 2018 to fully commit to FEMA's goal of two-dimensional (2D) modeling for all streams in the National Flood Insurance Program (NFIP) as a

standard practice. 2D modeling is performed with the U.S. Army Corps of Engineers (USACE) free software, which is an industry standard, called HEC-RAS 6.X. This sweeping update in the technology is a real boon to the nation in its ability to more accurately define risk from flooding. The USACE released a 2D version in 2018 to get the software available for use knowing that it had a few components that needed additional functionality developed. SEMA's forward thinking allowed it to maneuver, though this Business Plan process, to switch to the 2D process and provide the most accurate modeling for its 6+ million citizens.

The additional software components have now been developed by the USACE and released as HEC-RAS 6.0 in December 2020 in a beta version which became final in May 2021. It is anticipated by the industry that this will be the standard for modeling for the next decade or longer. With forethought, SEMA made the decision to move it's normal request for funding map panel production and post preliminary processing forward one year and use the normal request for those funds to get all of the models not currently effective switched to the 6.0 type models to give them a much longer shelf life. The key model updates are the ability to model bridges as unsteady bridges versus simulating with culverts as well as having spatially varying excess rainfall across the 2D model area. Infiltration now occurs in HEC-RAS as opposed to occurring outside the model and then inputting the single values for the modeled areas. This is underway as shown in **Figure 4.9** below. There are a few streams that flow from Iowa into Missouri being studied by SEMA and shared with Iowa to avoid duplication of efforts.

The proposed 5-Year funding plan assures that all 114 counties plus St. Louis City will be updated with needed new 2D modeling using the newest topography available.

Figure 4.9. Missouri Counties Currently Undergoing 2-D Modeling Updates



Source: SEMA Risk MAP Program 2022 Combined Strategic Business Plan

The Goals that SEMA has developed for the program to meet the overarching intent are:

- 100% 2D modeling statewide as either regulatory or Base Level Engineering (BLE) data
- Model-based Special Flood Hazard Area (SFHAs) Statewide on USGS 3-DEP accuracy compliant LiDAR
- Eliminate Flood Insurance Rate Map (FIRM) Paper Inventory (PIR) Statewide
- Reach and maintain greater than 90% NVUE Compliance Statewide
- Develop Flood Risk Products (FRD) that meet community needs Statewide
- Structure-Specific Flood Risk Assessments (FRA) within Communities
- Use Flood Risk Products (FRP) for Disaster Recovery investments for improved resilience
- Update risks for the State's two largest flooding sources, the Mississippi and Missouri Rivers.

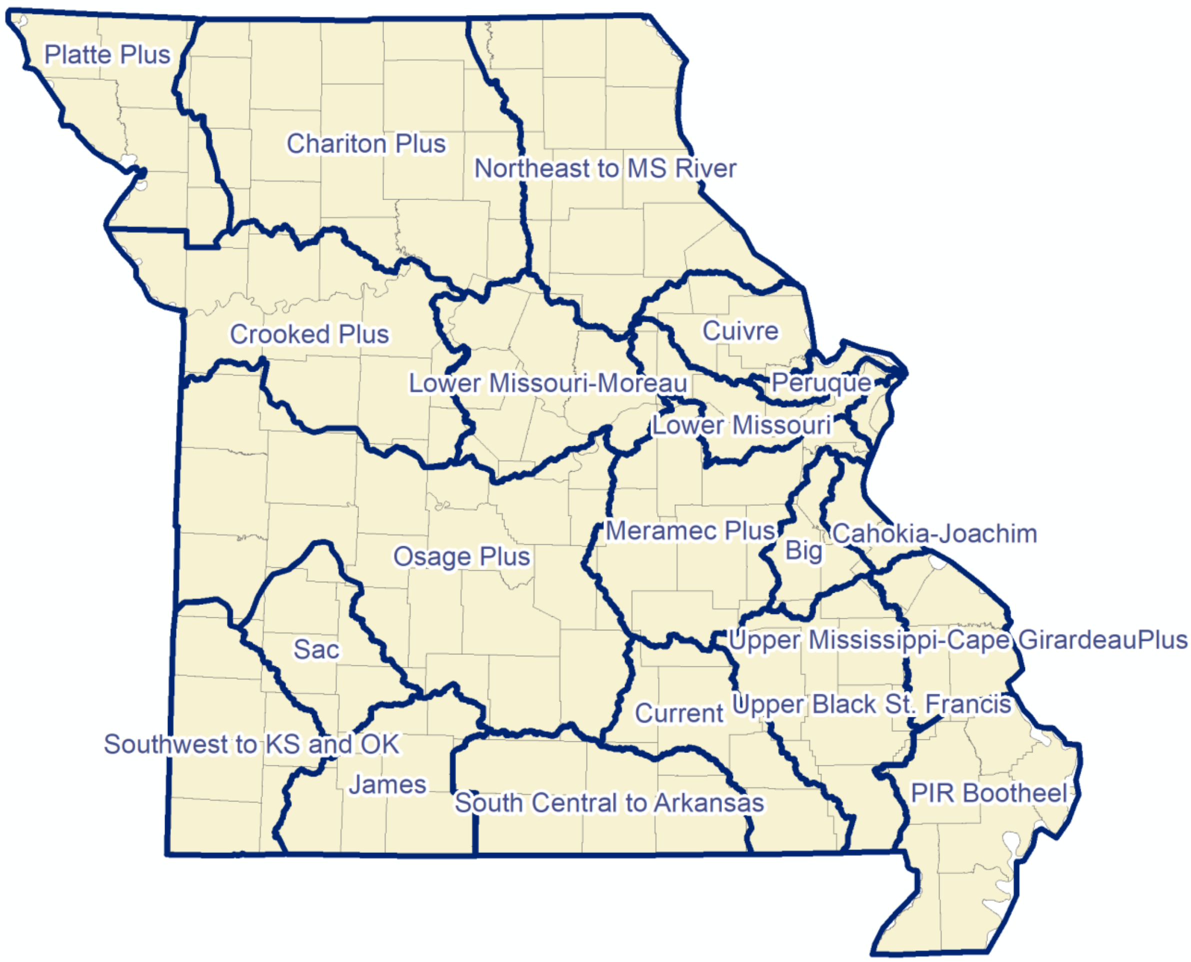
To accomplish this intent, SEMA has developed this 5-year Combined Strategic COMS and Business Plan to emphasize its comprehensive and integrated approach that includes floodplain mapping, risk assessment and mitigation planning by risk communication that meets or exceeds FEMA goals and program intent. This approach would get the state of Missouri starting "Statewide Map Maintenance" through Physical Map Revisions (PMR) by Fiscal Year (FY) 2024. These PMRs will provide mapping updates on individual streams, in rapid growth communities, areas that experienced a flood of record or other significant topographic accuracy changes, hydrologic and/or hydraulic changes, or other natural/man-made features that would alter the accuracy of the flood risk assessments (+/- feet). The Global Project Outreach and Planned Communication Plan (POPC) is included as part of the Appendices.

As with any data set, a strong plan for updates and maintenance is needed to maintain the value of the initial investment. Beginning in January 2016, FEMA provided an additional temporary program called Paper Inventory Reduction (PIR) to get these paper-only floodplain maps updated and digital. SEMA embraced this new allocation and through this plan has all 34 PIR County mapping updates funded with 15 of them already Effective. These databases are countywide, not watershed based, and define risk in previously unmapped areas. This provides uniform matching of floodplains at county boundaries while addressing any watershed wide hydrologic or hydraulic analysis needs.

In support of the Risk MAP watershed approach, Missouri Risk MAP Watersheds have been created that are a combination of the USGS HUC 8 and HUC 12 Watershed Boundaries, called Missouri Hydrologic Unit Codes (MHUC). These watersheds maximize the watershed areas to encompass FEMA's Stream Inventory called the Coordinated Needs Management Strategy (CNMS) database using the metrics for expiring New, Validated, or Updated Engineering (NVUE) miles while efficiently addressing the full extents of communities. These MHUC basins are shown in **Figure 4.10** below. The watersheds selected for funding are chosen based on the need for improved accuracy of risk in the area and the availability of quality topographic data in the watershed. Items that increased the priority of new projects include 1) areas without model backed risks, 2) areas with paper only maps (unmodernized), 2) FIRMs not based on LiDAR topography, 3) Areas without Flood Risk Products, and 4) areas without 2D models These watersheds will be provided the full suite of Risk MAP products such as Changes Since Last FIRM, Water Surface Elevations, Depth Grids, Freeboard Grids, Percent Annual Chance Grids and 30-year Chance Grids in additional to the regulatory products of the Flood Insurance Study, Flood Insurance Rate Maps (FIRMs) and the FIRM database. SEMA has begun the development of a web portal to distribute this information to the stakeholders of Missouri as well as provide an avenue to request and receive selected datasets.

In a progressive move to provide risk communication digitally nationwide, FEMA created the Automated Map Production (AMP) tool which utilizes the FIRM database to display and produce FIRMs "on-the-fly" online. Beginning with FY20 funding, SEMA is converting to only AMP FIRMs for any maps moving forward with 2D modeling, once again embracing the proactive approach to risk communications in support of the vision for risk reduction. **Figure 4.11** displays the counties that will have FIRMS produced with the AMP process with 2020 and 2021 funding.

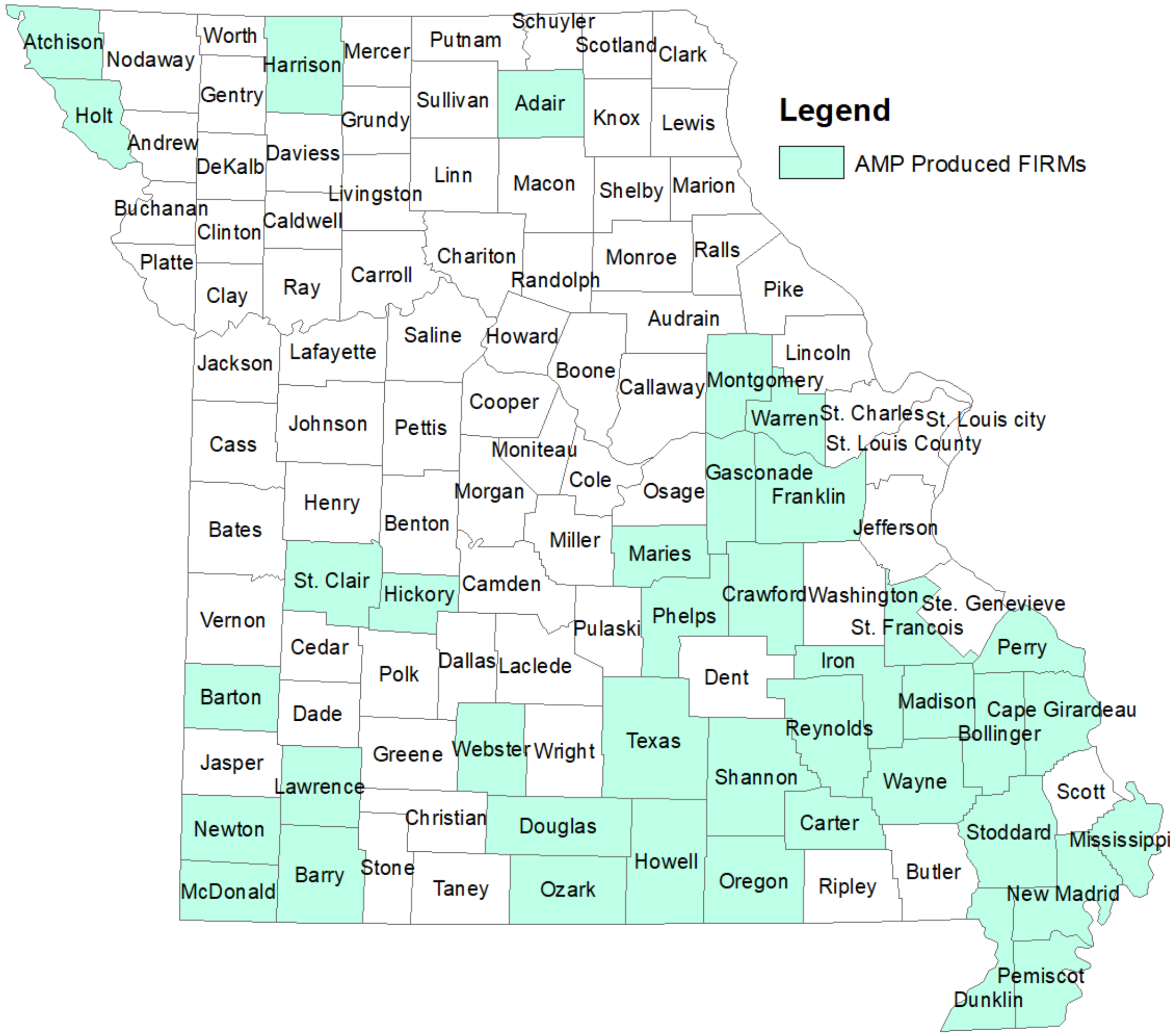
Figure 4.10. Missouri Unit Codes (MUC) for Risk MAP Study Approach



Source: SEMA Risk MAP Program 2022 Combined Strategic Business Plan

Recent major flood events that change hydrology will be incorporated into modeling updates. Development along streams will drive some studies to go from Base Level to Enhanced Level studies. There is a need in a few areas for updated risk assessments to support local Flood Control Projects. These updates also support the map maintenance with Physical Map Revisions (PMRs) and Letters of Map Revision (LOMRs).

Figure 4.11. FY20 and FY21 Funded Counties that will have AMP Produced FIRMs



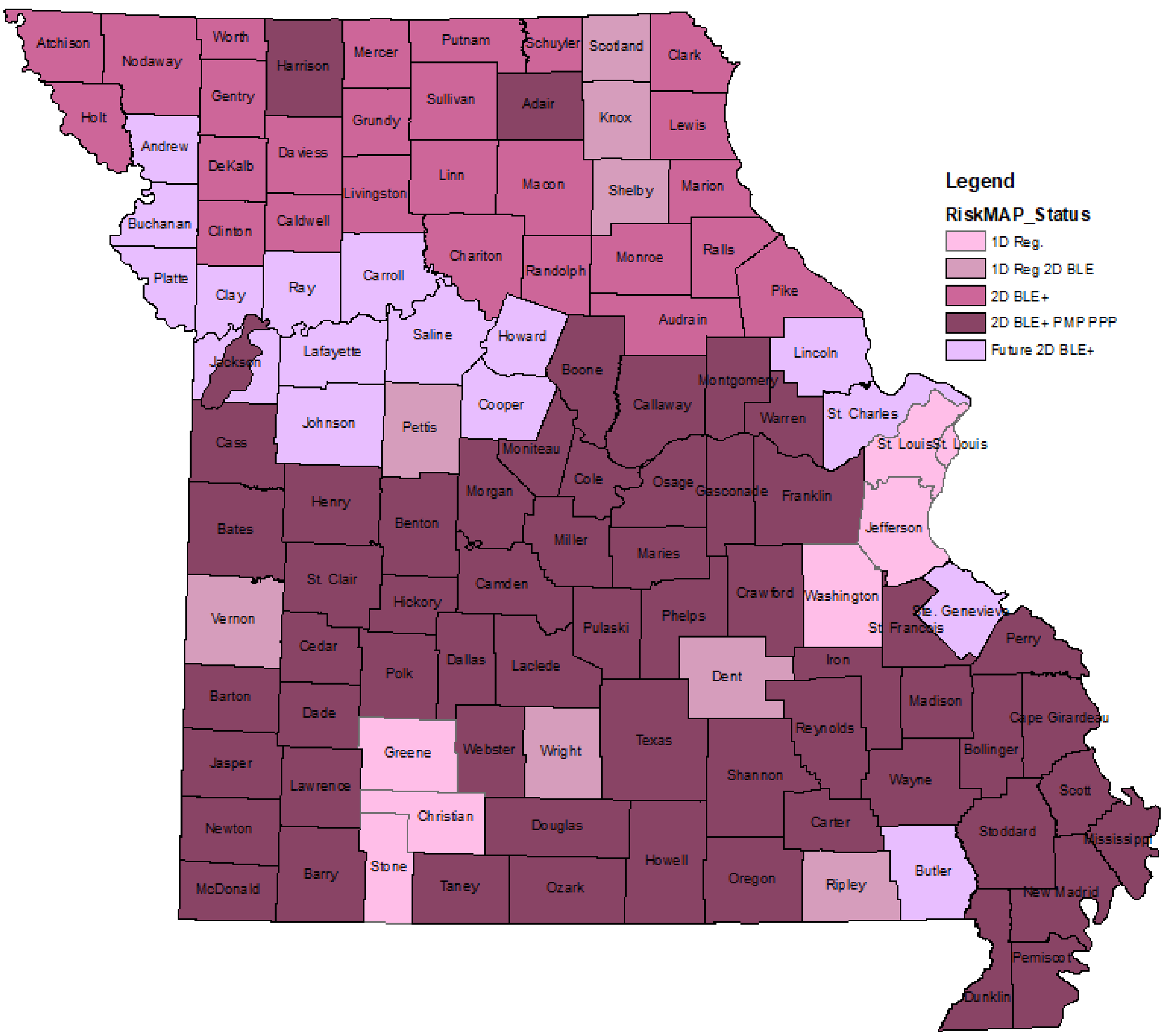
Source: SEMA Risk MAP Program 2022 Combined Strategic Business Plan

A Statewide Needs Assessment was conducted as part of this Business Plan to determine a path for getting Missouri at the 90% NVUE Valid status (Excellence Status) by FY24 and initiate PMR Map Maintenance starting in FY23. This plan actually plans for 100% (Excellent status) with the goal of 90% accounting for unknown changes across the state in current NVUE compliant streams. FEMA's stated or Expected goal is for 80% NVUE compliance. **Figure 4.12** summarizes the mapping status of each county. Counties fall into one of five categories:

1. The first category is 1D modeling regulatory on LiDAR based topography with Flood Risk Datasets (FRD). These are shown in **light pink** and are labeled as 1D Reg.
2. The second category is 1D modeling regulatory on LiDAR based topography with Flood Risk Datasets (FRD) plus 2D BLE models available, but which are not planned for 2D results to go through regulatory mapping updates at this time. They are shown in **medium pink** and are labeled as 1D Reg. 2D BLE.

3. The third category are counties in the discovery phase with 2D BLE models under development that are planned to move forward with regulatory mapping using 2D results. Shown in **dark pink** and are labeled as 2D BLE+.
4. The fourth category are counties with 2D models in data development with regulatory PMP funded/In progress meaning they have updated 2D modeling with FRD on the best available LiDAR-based topography with Risk MAP Flood Risk Dataset (FRD) products under development moving into Preliminary Map Production (PMP) with Post Preliminary Processing (PPP) planned. They are shown in **burgundy** and are called 2D BLE+ PMP PPP. This includes both PIR and watershed based Risk MAP studies.
5. The fifth category are counties with model-based maps using older LiDAR based topography for which there is newer LiDAR now available and only a partial suite or no FRD products are available. These counties will be discovered simultaneous with others in their MUC watershed for 2D modeling updates on the newer topography in the future. These counties are shown in **light purple** and are labeled as Future 2D BLE+.

Figure 4.12. FY20 and FY21 Funded Counties that will have AMP Produced FIRMs



Hazard Mitigation Planning

As of September 2022, there were-114 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives.

As with the NFIP, changing risk areas over time can pose a challenge with respect to development of risk assessments that take into account changing conditions. Changes in development that can impact future risk as well as changing future conditions due to climate trends that can impact future risk should be considered. This can present a challenge for local planners with respect to identifying risk areas that may be dynamic.

Use of Mitigation Funding

See Section 4.2.4, Review and Progress of Mitigation Actions and Section 7.5, Effective Use of Available Mitigation Funding.

Challenges in Use of Mitigation Funding include:

- SEMA's Mitigation Management program has historically maintained a staffing level to manage approximately $25 million in grants. However, due to the program's success in obtaining funding through the competitive Pre-Disaster Mitigation program and multiple disasters, SEMA has managed grant funds in excess of $100 million. This has created some challenges in staffing capacity to administer grants. SEMA has met this challenge by contracting with the Regional Planning Commissions for planning. Additionally, staffing in the Mitigation Management program has increased over time.

High Hazard Potential Dams Grant Program

As a new grant program, the initial program implementation challenges are coordination efforts with SEMA and MoDNR and the initial lack of resources to administrating the HHPD grant. Additional challenges impacting the vulnerability of HHPDs include identification of any unclear ownership of dams, sufficient capacity to conduct inspections of high hazard and significant hazard dams, increases in vulnerabilities due to the construction of new structures within the inundation areas of existing dams, and preparedness/response capabilities.

The Dam Safety Performance Report 2022 for Missouri, as published by the Association of State Dam Safety Officials, outlines the key components of an effective dam safety program. Topics include legislative authorities, permitting, inspection, enforcement, emergency action planning and response, education and training, and public communications. Those areas identified as needing improvement in Missouri include public relations, inspection, and education/training. The challenge, at a minimum, for SEMA and MoDNR is to address these specific areas. Missouri was rated highest on enforcement.

4.5.6. Opportunities for Improving State Capabilities

This section summarizes the opportunities for improving state capabilities.

National Flood Insurance Program Opportunities

As of May 2022, there are 194 communities that are mapped with identified special flood hazard areas that do not have flood insurance. This presents an opportunity to continue to work with those communities to encourage them to participate in the program so that residents and business owners in flood risk areas have the opportunity to purchase flood insurance to protect their financial investment.

Additionally, participation in the NFIP would facilitate future management of flood risk areas to prevent new development from increasing the number of structures at risk.

Community Rating System Opportunities

Of the top 50 Missouri communities (in terms of flood insurance policies in force), only 9 participate in the CRS (18 percent). The remaining 41 communities in the top 50 present an outreach opportunity for encouraging participation the CRS.

Risk Mapping, Assessment, and Planning (Risk MAP) Program Opportunities

Continued deployment of the Risk MAP program presents several opportunities to increase capabilities. The regulatory and non-regulatory products provide tools for community officials and planners to understand risk as well as take steps to minimize future risk. With the misconceptions that currently exist with the distinction of the 1-percent annual chance flood zones, the non-regulatory products provide additional resources to communicate risk. The Community Engagement and Risk Communication (CERC) component of Risk MAP is specifically designed to use the Risk MAP products to fully communicate risk as well as facilitate development of mitigation opportunities.

Hazard Mitigation Planning Opportunities

There are opportunities within the framework of local planning to address changing risk areas. With the implementation of the State Plan Guidance in March of 2013 and 2023, State Plans are now required to consider not only changes in development that can impact future risk, but also consider other changing future conditions due to climate trends that can impact future risk. This presents a basis for opportunities at the local planning level to incorporate this same type of adaptive planning. A hazard mitigation plan that addresses climate change in its risk assessment and includes adaptation actions in its mitigation strategy may reduce risk to current and future events.

Use of Mitigation Funding Opportunities

The State of Missouri has a long history of making use of available mitigation funding to reduce risk within the state. With the development of this State Plan Update, the State of Missouri has again made the decision to go above and beyond standard plan requirement with the development of an updated enhanced plan. This provides the opportunity for the State of Missouri to continue to receive increased post-disaster hazard mitigation funding from the standard amount of 15-percent to the enhanced amount of 20-percent of disaster recovery costs.

High Hazard Potential Dams Grant Program

As this a new grant program, SEMA and MoDNR have added a new mitigation action to meet on a quarterly basis to discuss the High Hazard Potential Dams Program (HHPD). Discussions will include vulnerabilities and consequences, dam incidents, deficiencies, mitigation actions, challenges, and possible solutions to lack of resources to administrating the HHPD grant. With the availability of this new funding mechanism, the State has an opportunity to pursue mitigation actions to address many of the challenges and vulnerabilities identified for dams within the State.

4.6. Local Capability Assessment

Requirement §201.4(c)(3)(ii): [The State mitigation strategy shall include a] general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.

The local capability assessment provides a general description of local mitigation capabilities in Missouri, including examples of successful policies and programs, followed by an analysis of the effectiveness of these capabilities. The assessment concludes with a discussion of opportunities and obstacles to implementing and strengthening local capabilities.

4.6.1. Local Policies, Programs, and Capabilities

There are a wide range of policies, programs, and capabilities that can serve as a foundation for implementing local mitigation plans including the following:

- Planning Capabilities
- Building Codes, Policies, and Ordinances
- Mitigation-related Programs/Partnerships
- Specific Studies
- Staffing Positions
- Potential Funding Sources

Planning Capabilities

County Emergency Operations Plans

Each County and the independent City of St. Louis have an Emergency Operations Plan in place to guide direction and control in response to a disaster. Many larger cities also maintain their own Emergency Operations Plan to guide response activities. The State Emergency Management Agency provides guidance to local entities in development/update of these plans.

Local Hazard Mitigation Plans

There are 114 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives.

Comprehensive Development Plans (Master Plan)

A comprehensive development plan is an official document adopted by a city as a policy guide to decisions about the physical development of the community. The plan is not a regulatory ordinance, but a guide to be used when regulatory ordinances are developed and administered. Nor is the comprehensive development plan a detailed capital improvement program showing precise locations of public improvements and community facilities; it is used as a guide in the more detailed development planning that must occur before those facilities are built. The plan is a comprehensive document in that it covers all portions of the city and all facilities that relate to development.

Planning and Zoning

Planning and zoning is the mechanism with which municipalities design and control the development of private land. All cities, towns and villages in Missouri may adopt planning and zoning. Statutory authority to enact planning and zoning is found in Chapter 89 of the Revised Statutes of Missouri

(RSMo). Chapter 89 establishes the procedural framework in which planning and zoning is enacted and administered. Planning and zoning gives municipal officials the opportunity to coordinate development activities within their community. Without this tool, land use decisions are left to the whims of a wide variety of private groups that are motivated by personal interests instead of the public interest.

According to a 2015 survey by the Missouri Municipal League, 417 out of 686 municipalities that responded have Planning and Zoning (see **Table 4.16**).

Table 4.16. Municipalities with Planning and Zoning by County (Responded to Survey)

County	Yes	No	Not Reported	Total Responses
Adair	1	3		4
Andrew	2			2
Atchison	2	2		4
Audrain	3	3	1	7
Barry	5	4		9
Barton	1	3		4
Bates	1	3		4
Bates|Cass		1		1
Benton	3			3
Bollinger	1		2	3
Boone	6	3		9
Buchanan	3			3
Butler	1	2	1	4
Caldwell	2	5		7
Callaway	4	2		6
Callaway, Cole	1			1
Camden	4	3		7
Camden|Miller	1			1
Camden|Morgan	1			1
Cape Girardeau	2	1		3
Carroll	2	2	1	5
Carter	1	2		3
Cass	13	2		15
Cedar	1	1		2
Chariton	2	1		3
Christian	7	1		8
City Not Within A			1	1
Clark		4		4
Clay	13	1	1	15
Clay|Clinton	1			1
Clay|Ray	2			2
Clinton	5			5
Clinton, DeKalb	1			1
Clinton|DeKalb		1		1
Cole	3	2		5
Cooper	2	2	2	6
Crawford	4			4
Crawford, Franklin	1			1
Dade		3		3
Dallas	1	2		3
Daviess	1	3	1	5
DeKalb	1	3		4
Dent	1			1

County	Yes	No	Not Reported	Total Responses
Dent|Reynolds		1		1
Douglas	1			1
Dunklin	5	3		8
Franklin	6	1		7
Franklin|St. Louis	1			1
Gasconade	4	1		5
Gentry	2	1		3
Greene	7			7
Greene|Webster	1			1
Grundy	1	2	1	4
Harrison	1	5	1	7
Henry	4	4		8
Hickory		4		4
Holt	1	4		5
Howard	3			3
Howell	3			3
Iron	3	2	1	6
Jackson	12	3	1	16
Jackson|Cass	1			1
Jasper	9	4		13
Jasper|Newton	1			1
Jefferson	8	1		9
Johnson	3	3		6
Knox		3	1	4
Laclede	1	2		3
Lafayette	8	6		14
Lafayette|Saline		1		1
Lawrence	5	1		6
Lewis	1	3		4
Lincoln	3	6		9
Linn	2	3	2	7
Linn|Sullivan		1		1
Livingston	1			1
Macon	3	3	1	7
Madison	1	1		2
Maries		1		1
Maries|Osage	1			1
Marion	2			2
McDonald	5	2		7
Mercer		2		2
Miller	1	1		2
Mississippi	2	2		4
Moniteau		2		2
Monroe	3			3

County	Yes	No	Not Reported	Total Responses
Montgomery	4	1	1	6
Morgan	2	3		5
New Madrid	4	7		11
Newton	4	4		8
Nodaway	1	2	1	4
Oregon	1	2		3
Osage	1	2	1	4
Ozark	2	1		3
Pemiscot	2	1		3
Perry	1			1
Pettis	3	3		6
Phelps	2	3		5
Pike	3	3	1	7
Platte	14	1		15
Polk	2	4		6
Pulaski	3	2		5
Putnam	1			1
Ralls	3			3
Randolph	2	5		7
Ray	5	3		8
Reynolds		1		1
Ripley	1	1		2
Saline	3	1		4
Schuyler		3	1	4
Scotland	1	1		2

County	Yes	No	Not Reported	Total Responses
Scott	6	1		7
Shannon	1	2		3
Shannon|Texas		1		1
Shelby	2	2		4
St. Charles	12			12
St. Clair	2	2		4
St. Francois	6	2		8
St. Louis	71	6		77
Ste. Genevieve	1	2		3
Stoddard	3	3		6
Stone	4	4	1	9
Sullivan	2	1	1	4
Taney	5	2	1	8
Texas	3	2		5
Vernon	1	1		2
Warren	3	2		5
Washington	2	1	1	4
Wayne		3	1	4
Webster	3	2		5
Worth	1			1
Wright	2	2		4
Total Responses	**417**	**239**	**28**	**684**

Source: Missouri Municipal League, 2015

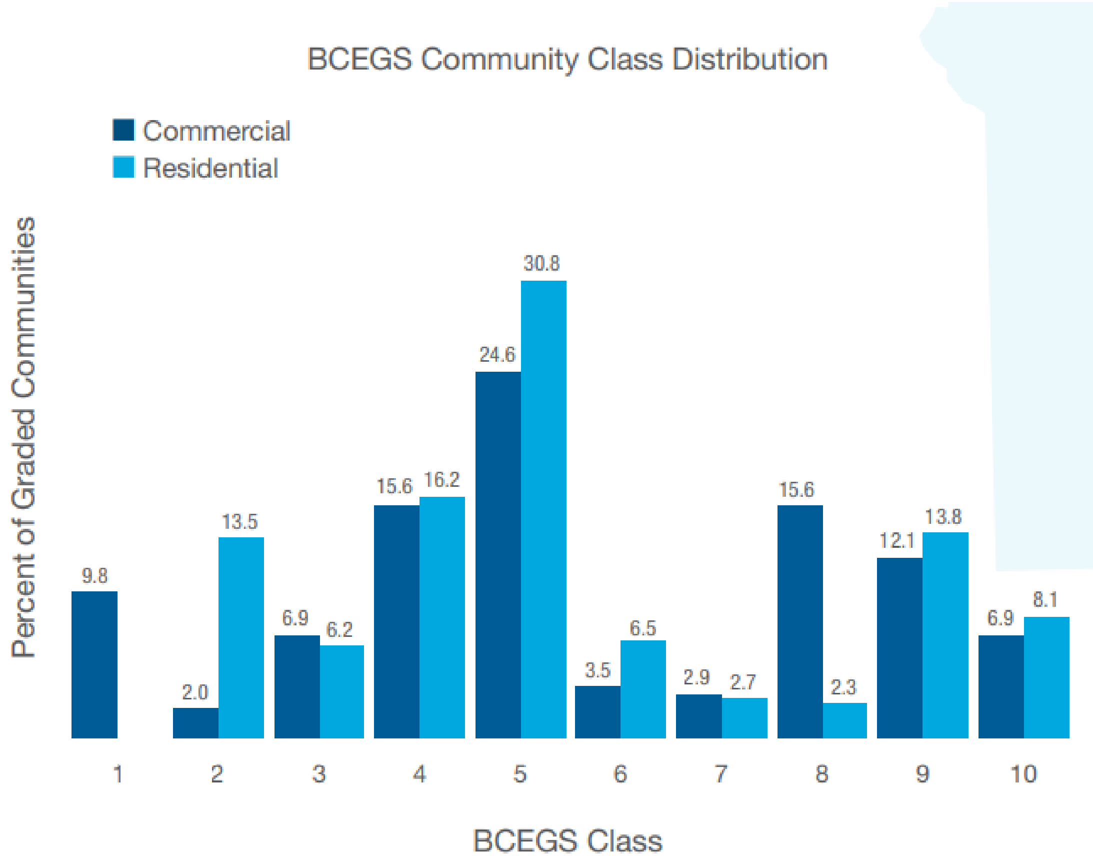
Building Codes, Policies, and Ordinances

Missouri does not have a mandated building code, so local jurisdictions are not required to have building codes.

Studies following the 1992 devastation from Hurricane Andrew indicated that lax enforcement of building codes had significantly increased the number and severity of claims and structural losses. That link between building code adoption and enforcement to potentially mitigate catastrophic losses ultimately resulted in the development of Insurance Service Office (ISO)'s Building Code Effectiveness Grading Schedule (BCEGS) program in 1995. The BCEGS program assesses a community's building code enforcement in three areas: code administration, plan review, and field inspection. Over 1,000 data points are collected to calculate two scores: one for one-and two-family residential construction and one for commercial or industrial construction. The scores range from 0 to 100 which are then translated to a scaled class rating of 1 (exemplary commitment to building code enforcement) to 10.

According to the 2015 National Building Code Assessment Report published by ISO, the average Building Code Effectiveness Grade Score for the State of Missouri is a Class 5 for both residential and commercial structures.

Figure 4.13. Missouri BCEGS Community Class Count, 2019



Source: National Building Code Assessment Report, ISO's Building code Effectiveness Grading Schedule, 2019

Seismic Design and Construction Ordinance

47 Counties in Missouri (41 percent) are within the State Statute, *RSMo 319.200-207*, and are required to adopt an ordinance requiring that new public construction and alterations comply with the standards for seismic design and construction of the BOCA code or UBC.

Floodplain Ordinance

Many local plans discuss the value of land use planning and building codes for hazard mitigation but are not able to implement these measures due to their designations by the State as third- or fourth-class counties. Approximately 89 counties that are designated as third class based on their assessed valuation cannot implement certain zoning, land use, and building regulations without voter approval. Among the restricted regulations are floodplain ordinances necessary to comply with the National Flood Insurance Program. *RSMo 49.600* mandates that no floodplain ordinance is effective unless authorized by voters in certain second-, third-, or fourth-class counties.

Mitigation-related Programs/Partnerships

Some local governments have intergovernmental or interagency committees that meet regularly. These organizations often take the form of an emergency management committee that meets monthly. Other

communities use their local emergency planning committee (LEPC) to coordinate emergency management and mitigation issues. LEPCs are required by the Emergency Planning and Community Right-to-Know Act of 1986. The purpose of this act is to encourage and support emergency planning efforts at the State and local levels and provide the public and local governments with information concerning potential chemical hazards. Membership of the LEPCs includes representatives of public and private organizations as well as representatives from every facility in the jurisdiction subject to the emergency planning requirements of the act. At least one Missouri county has combined their LEPC and emergency management committee into one entity; other counties have both types of committees operating simultaneously.

Many counties promote seasonal hazard awareness campaigns, such as severe weather awareness week. Many counties use their websites and social media such as Facebook to communicate information to residents about hazards. Many communities also do some education programs in elementary and secondary schools.

Community Rating System

The NFIP Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Activities credited by the CRS provide direct benefits to the community, including enhanced public safety, reduction in flood damage and environmental protection. Residents are reminded that the community is working to protect them from flood losses, and money stays in the community instead of being spent on insurance premiums. For communities that receive credit through public information activities, these build a knowledgeable constituency interested in supporting and improving flood protection measures.

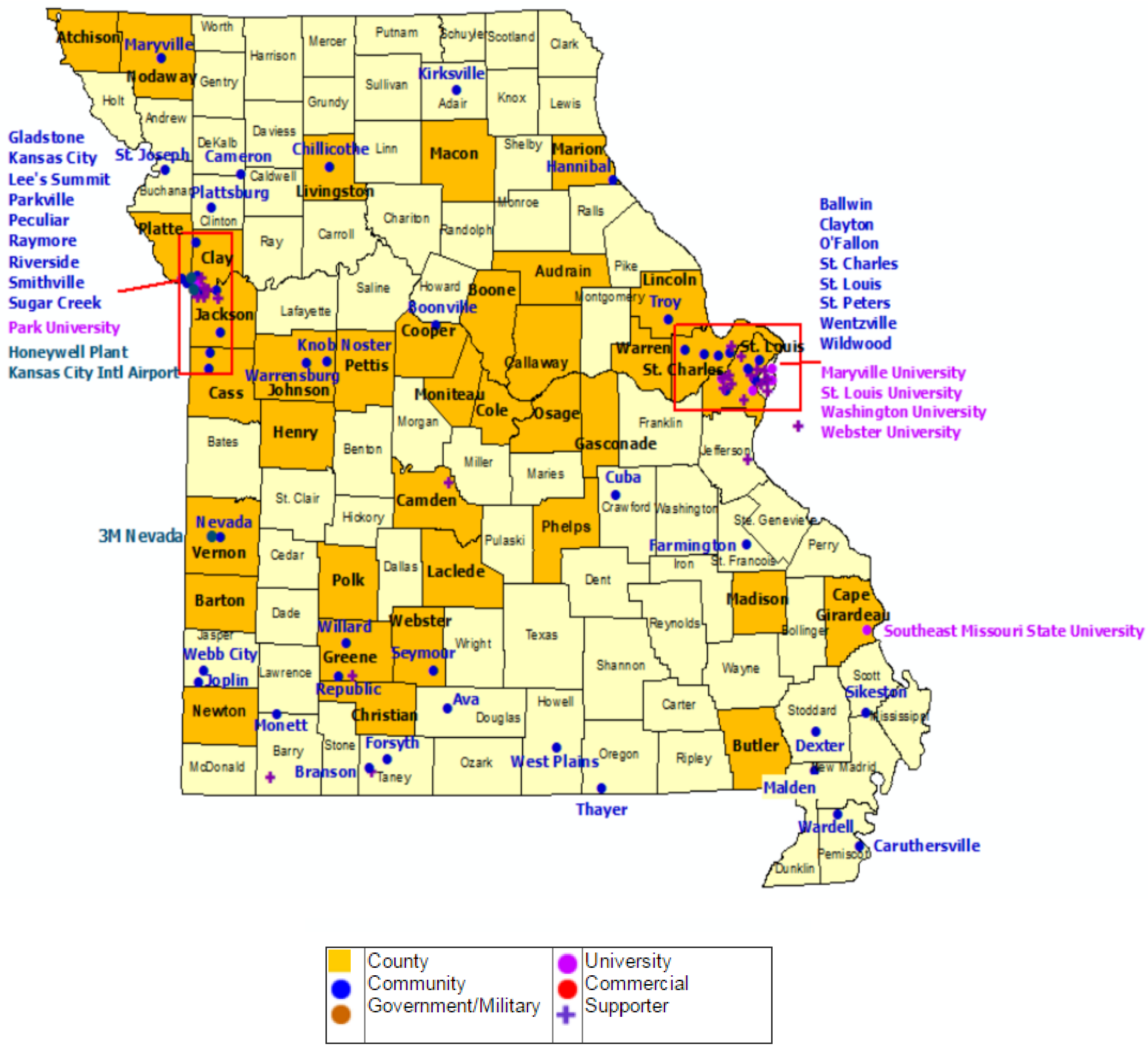
There are currently fifteen Community Rating System communities in Missouri as follows:

- City of Arnold – Class 10
- City of Blue Springs – Class 9
- City of Brentwood—Class 9
- City of Ferguson – Class 10
- City of Florissant—Class 8
- City of Hannibal—Class 9
- City of Independence—Class 9
- City of Kansas City –Class 7
- City of Kirkwood – Class 10
- City of Lee's Summit – Class 9
- Lincoln County—Class 7
- City of Maryland Heights—Class 7
- City of O'Fallon—Class 9
- Platte County—Class 5
- St. Charles County—Class 7

NOAA StormReady®

StormReady® is a voluntary program that was developed by the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) to help communities better prepare for and mitigate effects of all types of severe weather—from tornadoes to flooding. In Missouri, there are 84 StormReady® Designated communities as seen in **Figure 4.13** below.

Figure 4.14. Storm Ready® Designated Communities in Missouri



SourceNational Weather Service StormReady® Program, http://www.weather.gov/stormready/mo-sr

Table 4.17. StormReady® Designated Communities in Missouri

Counties		Communities			
Andrew	Jackson	Ava	Forsyth	Malden	Smithville
Atchison	Johnson	Ballwin	Gladstone	Maplewood	St. Charles
Audrain	Lincoln	Belton	Hannibal	Maryville	St. Joseph
Barton	Livingston	Boonville	Hayti	Monett	St. Louis
Boone	Macon	Branson	Independence	Nevada	St. Peters
Butler	Madison	Cameron	Joplin	O'Fallon	Sugar Creek
Callaway	Nodaway	Caruthersville	Kansas City	Parkville	Thayer
Camden	Pettis	Chillicothe	Kennett	Peculiar	Troy
Cape Girardeau	Platte	Clayton	Kirksville	Plattsburg	Wardell
Christian	Polk	Cooter	Knob Noster	Raymore	Warrensburg
Clay	St. Charles	Dexter	Lee's Summit	Republic	West Plains
Cole	St. Louis	Farmington	Louisiana	Rich Hill	Wildwood
Cooper	Vernon			Riverside	Willard
Greene	Warren			Seymour	
	Webster				

Government/Military Sites	Universities	Supporters	
Fort Leonard Wood	Park University	American Century Investments	SSM DePaul Health Center
Whiteman Air Force Base	St. Louis University	Battlefield Mall	SSM St. Joseph Health Center
Commercial Site	Washington University	Busch Stadium/St. Louis Cardinals	SSM St. Joseph Health Center-Wentzville
3M Nevada	William Woods University	Branson Airport	SSM St. Joseph Health Center-West
Honeywell Plant		Charles B. Wheeler Airport	SSM St. Mary's Health Center
		FEMA Region VII Headquarter	St. Louis Premium Outlets
		Independence Centers	St. Louis Zoo
		KCTV5, *Kansas City*	Taubman Prestige Outlets
		Osage Beach Premium Outlets	Urban Chestnut Brewery
		SSM Cardinal Glennon Children's Medical Center	Worlds of Fun
		SSM St. Clare Health Center	

Source: National Weather Service StormReady® Program, http://www.weather.gov/stormready/mo-sr

Firewise

The National Fire Protection Association's (NFPA) Firewise Communities Program encourages local solutions for safety by involving homeowners in taking individual responsibility for preparing their homes from the risk of wildfire. Firewise is a key component of Fire Adapted Communities – a collaborative approach that connects all those who play a role in wildfire education, planning and action with comprehensive resources to help reduce risk.

The program is co-sponsored by the USDA Forest Service, the US Department of the Interior, and the National Association of State Foresters.

To save lives and property from wildfire, NFPA's Firewise Communities program teaches people how to adapt to living with wildfire and encourages neighbors to work together and take action now to prevent losses. We all have a role to play in protecting ourselves and each other from the risk of wildfire.

Using a five-step process, communities develop an action plan that guides their residential risk reduction activities, while engaging and encouraging their neighbors to become active participants in building a safer place to live. Currently, there are no firewise participants in Missouri. Previously 13 communities and or fire protection districts participated in the program. This is an area for future growth and emphasis.

Staffing Positions

All 114 counties in Missouri have an Emergency Manager position and currently none are vacant.

Other personnel capabilities vary greatly across the State. Larger counties have full-time planners, engineers and geographic information System coordinators; smaller, less affluent counties do not have these positions. To some degree, the Regional Planning Commissions (RPCs) that are contracted by the State to develop local hazard mitigation plans, supplement local staffing by providing planning assistance, including GIS support.

Of 631 municipalities that responded to a 2015 survey from the Missouri Municipal League, 183 had less than four employees, 157 had 4-10 employees, 79 had 11 to 20 employees, 99 had 21- 50 employees, 54 had 51-100, and 59 had over 100 employees

Potential Funding Sources

The analysis of local plans revealed that most local governments do not have specific local funding sources for mitigation and rely on federal programs, such as the HMGP, BRIC and FMA Programs, to fund pre- and post-disaster mitigation projects. Through tax-funded investments in infrastructure improvements, local governments are able to fund some projects that have mitigation effects, such as replacing culverts or structural improvements to critical facilities. These funds come predominantly from property and sales tax revenues and are generally allocated directly to schools, public works, and other essential government functions. Mitigation can be accomplished with this revenue stream through projects that meet multiple objectives. For instance, money allocated for school repairs can be used to replace a school's roof with better wind resistant materials.

Some counties and municipalities have dedicated transportation or capital improvements sales or use taxes that can be obligated to fund mitigation projects. Many counties have fully allocated their current tax collections and do not have significant additional amounts for mitigation projects. A sales tax or bond issue to help fund mitigation actions would require a vote of the citizenry and could be difficult to pass.

4.6.2. Effectiveness of Local Mitigation Capabilities

To analyze the effectiveness of local mitigation policies, programs, and capabilities in accordance with Requirement §201.4(c)(3)(ii), a survey was developed for the 2018 State Hazard Mitigation Plan to obtain input from local governments, state, federal, and stakeholder agencies. In all, 100 responses were received to the survey. The remainder of this section summarizes the results of the survey. **Table 4.18** provides a summary of the types of entities that responded to the survey.

Table 4.18. Number of Responses for Each Type of Entity

Type of Entity	% of Responses	# of Responses
City Government	40.00%	40
School District	20.00%	20
County Government	15.00%	15
Other	9.00%	9
Private Non-Profit	5.00%	5
Private For-Profit	5.00%	5

Type of Entity	% of Responses	# of Responses
Regional Planning Commission/Council of Governments	5.00%	5
State Agency	1.00%	1
Federal Agency	0.00%	0

Respondents were asked the following question: "In your opinion, please rate the effectiveness of the following Local Mitigation Capabilities to Contribute to mitigation of damage from hazard events IN YOUR Community. (Opinions of State, Federal, and other agencies may refer to your experience statewide)". Response choices were: Highly Effective = 3, Somewhat Effective =2, Not Effective = 1, and Not Applicable = 0. **Table 4.19** provides the summarized results of the responses to this question. According to the survey respondents, warning systems are considered to be the most effective local mitigation capability followed by the emergency operations plan, the local/countywide / regional hazard mitigation plan, generators, and flood risk studies (including Risk MAP).

Table 4.19. Effectiveness of Local Mitigation Capabilities

Local Mitigation Capabilities	Weighted Average
Warning Systems (tornado/flood)	2.51
Emergency Operations Plan	2.41
Local / Countywide / Regional Hazard Mitigation Plan	2.31
Generators	2.28
Flood Risk Studies (including Risk MAP)	2.25
Floodplain Management Regulations	2.23
Firewise Program	2.21
Comprehensive / Master Planning	2.18
Planning / Zoning Ordinance	2.17
National Flood Insurance Program's Community Rating System	2.12
StormReady Program	2.12
Hazard Awareness/Public Information Programs	2.12
Stormwater Management Regulations	2.10
Building Codes	2.07
Subdivision Regulations	1.89
Earthquake Design Requirements	1.83

The final question in the survey asked respondents to rate their jurisdiction based on their opinion of how proactive their jurisdiction is in implementation of mitigation initiatives. **Table 4.20** summarizes the results of this question.

Table 4.20. Level of Proactiveness in Implementation of Mitigation Initiatives

Level of Proactiveness	# of Responses	% of Responses
Not Proactive in Mitigation	7	7.07%
Somewhat Proactive in Mitigation	60	60.61%
Highly Proactive in Mitigation	30	30.30%
Not Applicable or Unknown	2	2.02%

4.6.3. Opportunities for Improving Local Capabilities

This section discusses opportunities for strengthening local capabilities that have been identified based on the analysis of local programs, policies, and capabilities. The State will use these opportunities to strengthen local capabilities identified in this assessment and to update their mitigation strategy and enhance local planning coordination.

Local Funding

The analysis of local plans indicates that most local governments use federal funds for implementation of mitigation projects. Local governments have met federal mitigation program match requirements for mitigation projects through in-kind services, local general funds, and state general revenue; however, state general revenue is no longer available for this purpose due to budget constraints.

One approach communities are using to overcome this funding obstacle is by improving the integration of mitigation plans with other local plans and programs, such as capital improvement plans. This helps to achieve mitigation through other community objectives. Another approach is taking cost-effective mitigation measures into consideration when developing capital improvement projects.

A dedicated tax revenue source for mitigation is difficult to implement because tax increases are generally unpopular with the public. The public is also often unaware of the real costs of disasters and benefits of mitigation. Continued public education and awareness of hazard vulnerabilities and mitigation options may help attract funding for mitigation through tax dollars and private sources. The best time to implement such a campaign is in the immediate aftermath of a disaster. A tax designated to targeted, tangible benefits, such as funding an emergency manager position and/or an advance warning system, may be more acceptable to the public. The State has had local success with federal funding programs by efficiently managing the programs and providing assistance to local governments with applications, ideas for meeting match requirements, and continued eligibility.

Public Education and Outreach

Public education and awareness about natural hazards risks and mitigation is an important component in most local plans. Education and outreach has led to greater household preparedness, public participation in and support for mitigation policies and programs, as well as political support to address and fund mitigation needs. Seasonal hazard awareness campaigns are one outreach tool that many local governments use to enhance public awareness.

Technical Support

GIS and other technical assistance from the State remains an important resource for smaller communities with limited capabilities. Regional Planning Commissions (RPCs) provide additional GIS and technical support to communities who need such assistance. The State has helped and will continue to help local governments with limited capabilities overcome this obstacle by collecting information on what types of technical assistance are needed. To further assist local governments with their planning, SEMA is sharing the data collected in development of the State Hazard Mitigation Plan through the Web-Accessible Risk Assessment Data Layers and PDF Map-maker for Local Planner Access that was developed in conjunction with this plan update (See **Section 3.3** for additional information).

Regional Planning

The use of RPCs in Missouri to facilitate local mitigation planning has been quite effective (see Section 5, Coordination of Local Mitigation Planning for more information). As mentioned previously, the RPCs are important resources to strengthen local technical capabilities. Regional planning efforts also enable the coordination of land use issues to prevent one jurisdiction from engaging in activities that adversely impact another. As local governments begin to update their local hazard mitigation plans, partnerships with the RPCs will allow the State to exchange information and reinforce capabilities with local governments.

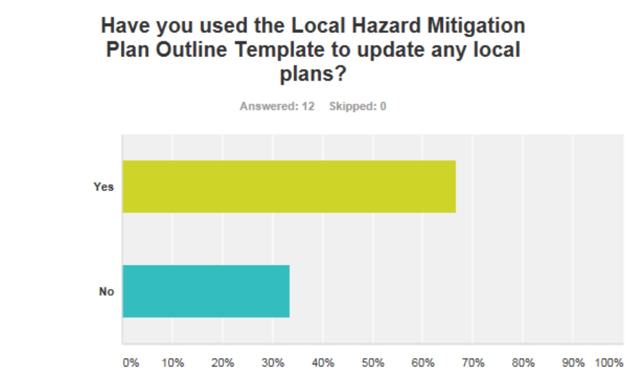
Local Plan Update Guidance and Training

As a part of its ongoing support to local communities, SEMA has created a Hazard Mitigation Plan Outline to use for local plans. This Plan Outline provides a framework/format for development of local hazard mitigation plan updates. It is organized with headings and subheadings to present meaningful information as well as ensure compliance with the local hazard mitigation planning requirements. The Plan Outline includes some sample text as well as instructions on the information that should be included under each heading / subheading. The Plan Outline also serves to provide useful resources and links where data may be researched and obtained.

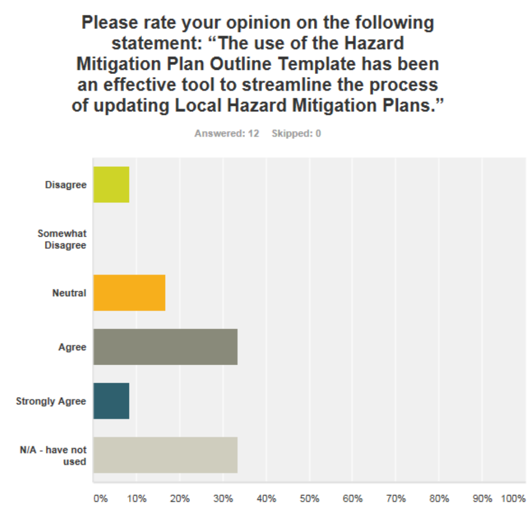
Use of the Plan Outline promotes greater consistency among plans, allowing information from the local plans to roll up to the State Plan more effectively as well as allow data from the State Plan to roll down to the local plans. This system provides continuity of data and planning efforts which increases the success of meeting goals while also reducing the duplication of effort in creating both local and State Plan updates. To support the Plan Outline, SEMA has also provided a series of workshops for local hazard mitigation planners focused specifically on use of the Plan Outline. Each year since 2015, three on-site planning workshops have been provided throughout the state after the State Hazard Mitigation Plan has been updated and approved by FEMA.

Prior to the workshops in 2017, the Regional Planning Commissions completed a survey related to the use of the Plan Outline. Results of this survey are provided in **Figure 4.15** and **Figure 4.16**.

Figure 4.15. Regional Planning Commission Survey Results – Use of Outline

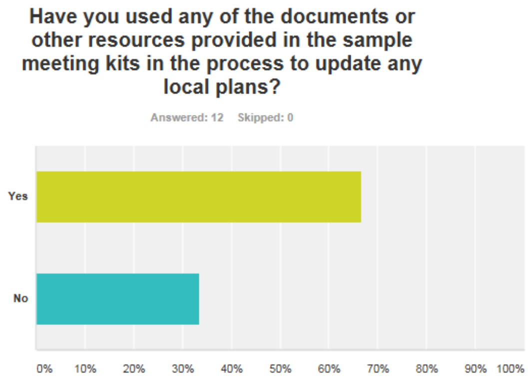


Answer Choices	Responses	
Yes	66.67%	8
No	33.33%	4
Total		12

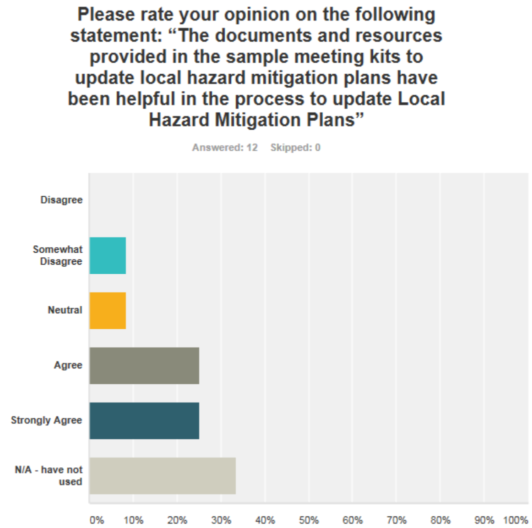


Answer Choices	Responses	
Disagree	8.33%	1
Somewhat Disagree	0.00%	0
Neutral	16.67%	2
Agree	33.33%	4
Strongly Agree	8.33%	1
N/A - have not used	33.33%	4
Total		12

Figure 4.16. Regional Planning Commission Survey Results – Use of Meeting Kits



Answer Choices	Responses	
Yes	66.67%	8
No	33.33%	4
Total		12



Answer Choices	Responses	
Disagree	0.00%	0
Somewhat Disagree	8.33%	1
Neutral	8.33%	1
Agree	25.00%	3
Strongly Agree	25.00%	3
N/A - have not used	33.33%	4
Total		12

In July 2017, FEMA issued a "Mitigation Best Practices" publication highlighting the SEMA Plan Outline Template for local hazard mitigation plans. The article, titled "Hazard Mitigation Local Plan Made Easy" states that the plan outline is "not only user friendly but also minimizes the chance of the local plan being returned numerous times for corrections" (see **Figure 4.17**).

In October 2021, FEMA issued the publication "Using Hazus for Mitigation Planning" which uses the State of Missouri has an example for the incorporation of Hazus results into mitigation planning (**Figure 4.17**). For the 2018 State Plan Update, the Missouri State Emergency Management Agency (SEMA) used Hazus to model flood vulnerability and estimate flood losses for all 114 counties and the City of St. Louis. Additional hazard data inputs were utilized, as available, to perform Level 2 Hazus analyses. This included the extensive use of the FEMA special flood hazard area data and Risk MAP flood risk datasets. These Hazus results were then provided to the local communities for use in local mitigation plans.

Figure 4.17. Mitigation Best Practices – Hazard Mitigation Local Plan Made Easy, 2017; and Using Hazus for Mitigation Planning, 2021

BEST PRACTICES FEDERAL EMERGENCY MANAGEMENT AGENCY July 2017

Mitigation Best Practices

Mitigation Working in Missouri DR-4317

Hazard Mitigation Local Plan Made Easy

Missouri State Hazard Mitigation Plan 2018

Photo of the State of Missouri Hazard Mitigation Plan which includes local plans. *Photo courtesy of Elizabeth Weyrauch*

JEFFERSON CITY, Mo. – Although mitigation plans are considered the key to breaking the cycle of disaster damage, reconstruction, and repeated damage, creating the plan or even updating an existing plan can be challenging. Plans have to be developed at the local level and then become a part of the State Hazard Mitigation Plan prior to FEMA's acceptance of the state's plan. In response to these issues, a State Hazard Mitigation Officer (SHMO) has devised a plan outline that is not only user friendly but also minimizes the chance of the local plan being returned numerous times for corrections.

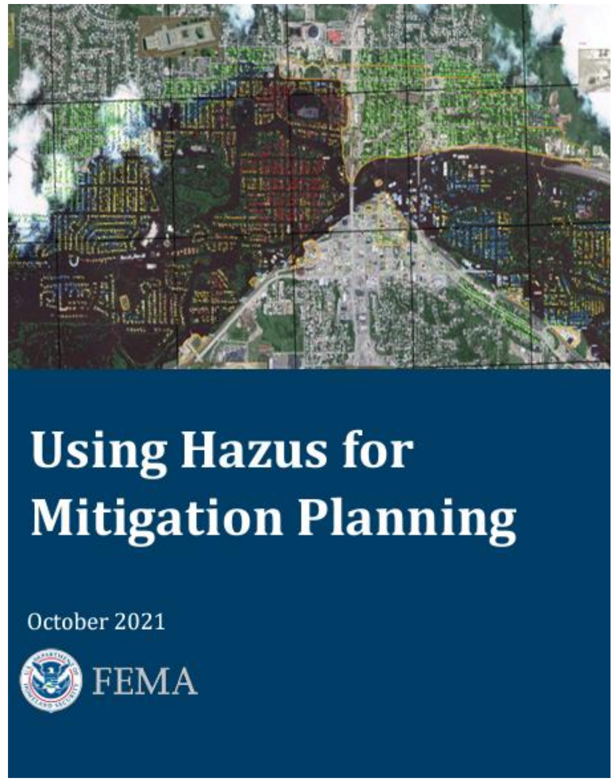
Elizabeth Weyrauch, SHMO for Missouri is pleased with how well the plan outline has been received.

"We all know that planning is essential," Weyrauch said. "People often view plans as obstacles, something they have to do. But it's an opportunity to develop resiliency. So we developed an outline for local plans that gives planners simple language, a format, plan guidance and relevant data sources. When the format for local plans is consistent, the plans can easily roll up into the state's master plan."

Created in handbook format, the plan outline includes:

- Instructions on how to use the outline
- An executive summary
- Chapters

This publication was produced by FEMA Region VII Mitigation Division as a part of DR-4317-MO



Land Use Planning and Regulations

Local governments are using land use planning to identify areas at risk to natural hazards and to keep those areas from developing inappropriately. Local governments are also starting to look at the negative impacts of existing and future planned subdivision developments and what measures can be implemented to reduce or eliminate them. Combinations of stormwater retention/detention projects along with locally funded buyouts are making a significant difference in this area.

Floodplain Management

Local governments rank floodplain management and NFIP as highly effective mitigation capabilities. Floodplain management and the NFIP remain key opportunities to strengthen local capabilities. The State has facilitated this by continuing to enhance its program that encourages and supports new participation in the NFIP and in the CRS Program. Additionally, the State is helping existing participants in the NFIP and CRS promote and enforce their floodplain management programs.

5 COORDINATION OF LOCAL MITIGATION PLANNING

5.1. Local Funding and Technical Assistance

Requirement §201.4(c)(4)(i): [The section on the coordination of local mitigation planning must include a] description of the State process to support, through funding and technical assistance, the development of local mitigation plans.

5.1.1. Background

Per DMA 2000, all local governments must have a hazard mitigation plan approved by FEMA to receive project grants from the HMGP, Building Resilient Infrastructure and Communities (BRIC), and Flood Mitigation Assistance Program. It is the role of the State to provide assistance to local governments for plan development and to ultimately use the local plans to improve the statewide plan.

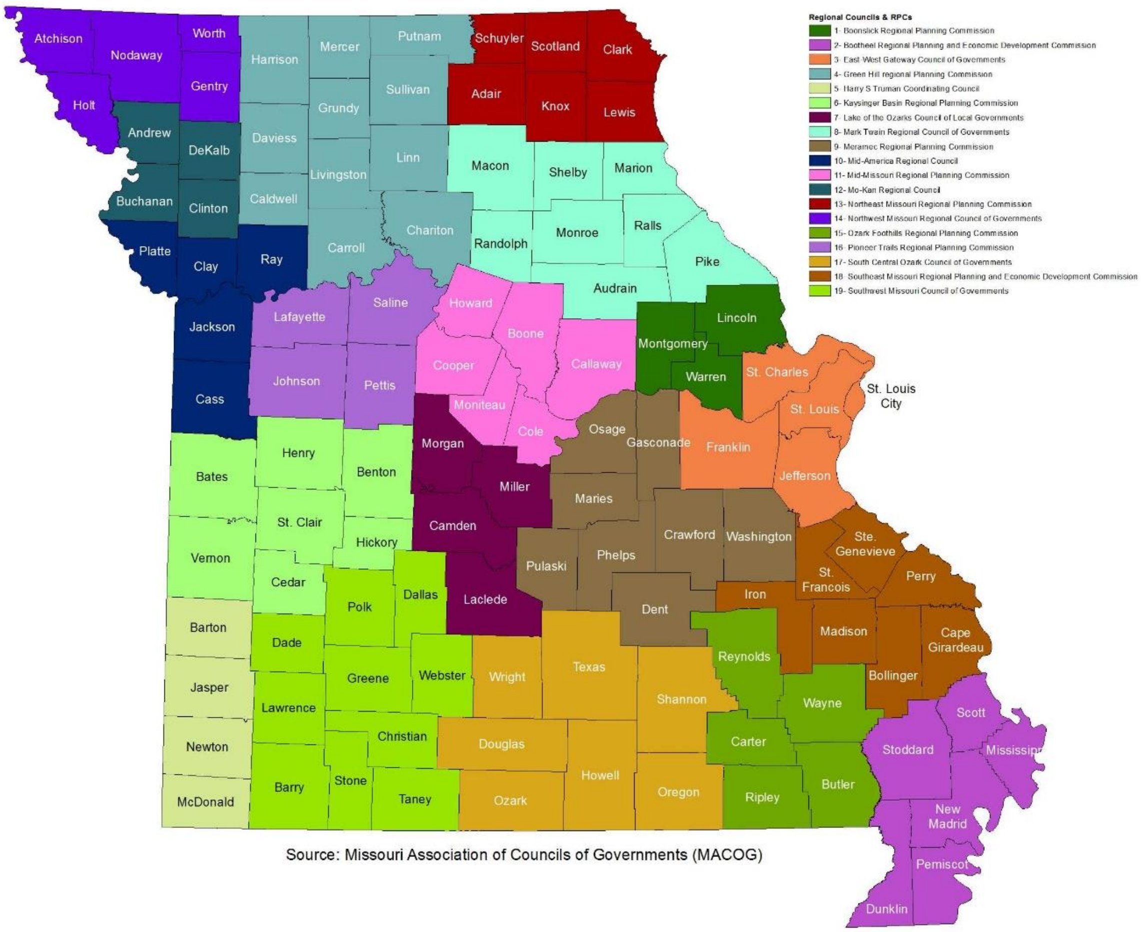
When the 2004 version of the Missouri State Hazard Mitigation Plan was being compiled, local community mitigation plans were largely unavailable and local community information was limited. Now, through multiple state plan updates, the local community information continues to improve. Back in 2004, SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch reviewed all the options and decided to contract the Missouri Association of Councils of Government (MACOG), the umbrella organization for Missouri's 19 Regional Planning Commissions/Councils of Government (RPCs) (see Figure 5.1), for help with the development of multi-jurisdictional county-level plans. This remains the current process for the development or updates to the multi-jurisdictional county-level plans. With guidance and prioritization (see Section 5.3 Prioritizing Local Assistance) from SEMA, RPCs were asked to develop mitigation plans for the counties in their region that would:

- Meet the requirements of DMA 2000 for local hazard mitigation plans
- Include the unincorporated and incorporated parts of the county, regardless of population
- Include the public school districts
- Specifically address natural hazards and mitigation strategies and initiatives for each incorporated jurisdiction

Because of two presidentially declared disasters in 2002 (DR 1403 and DR 1412) and one in 2003 (DR 1463), SEMA had a limited amount of planning funds that they allocated to fund the RPCs' local hazard mitigation planning efforts. Counties that did not receive initial funding were provided with planning documents, guidance, and information from SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch. As more funding for planning became available, SEMA's Recovery Division, Mitigation Management Section now uses a list of questions to help prioritize how best to distribute the funds (see Section 5.3 Prioritizing Local Assistance).

In November 2007, SEMA added a Lead Planner to their staff. This planner provides technical assistance with local mitigation plan projects and has assisted in the increase in overall effectiveness of the local plans. The Mitigation Planner is able to give the local RPC planners ideas for specific hazards data, sample vulnerability analysis based on available data for their area, thus creating a more detailed local multi-hazard mitigation plan particularly for more vulnerable jurisdictions (i.e. highly populated communities).

Figure 5.1. Missouri Regional Planning Councils



Source: Missouri Association of Councils of Governments (MACOG)

5.1.2. Status of Local Plan Development

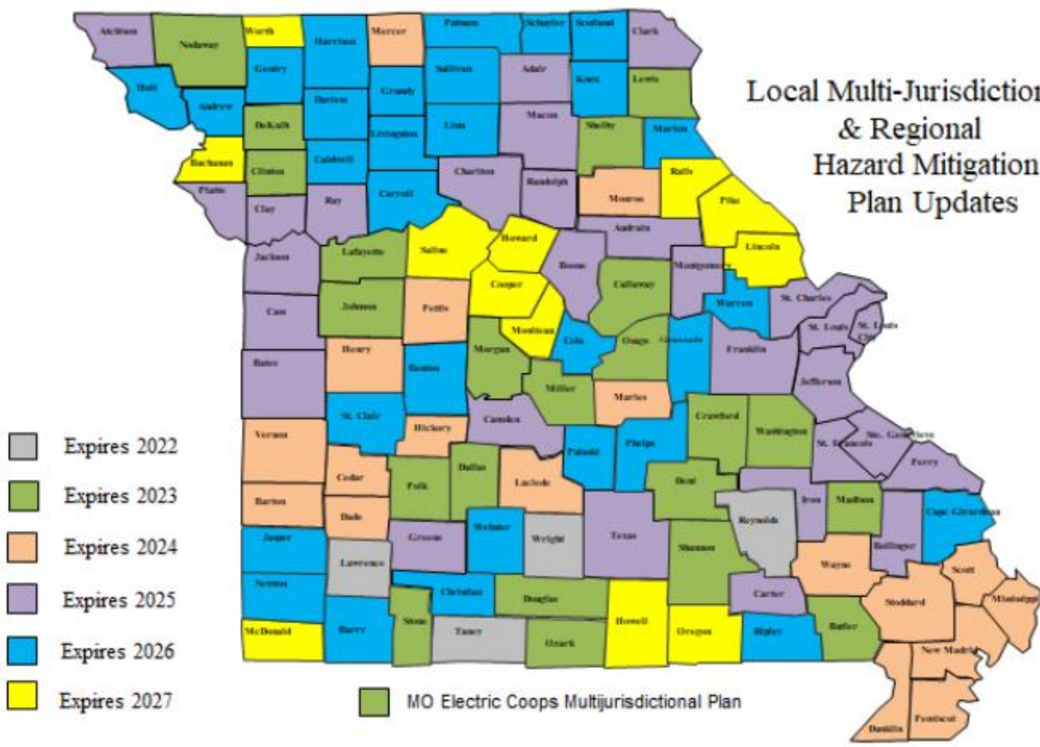
As of July 2022, 114 of the 114 or 100% of Missouri counties (plus the independent City of St. Louis) had FEMA-approved hazard mitigation plans that met the requirements of both the DMA 2000 and the Hazard Mitigation Assistance Program (see **Figure 5.2**). All counties, and the Missouri Electrical Cooperatives, have mitigation plans.

With many county-level plans available, SEMA can effectively coordinate its efforts with local jurisdictions and assess how to most efficiently distribute project funding, technical assistance, and training. Section 5.1.3 describes the process the State uses to provide planning support to local jurisdictions and the types of funding and technical assistance they make available for initial and future planning efforts. A list of the Missouri Local Hazard Mitigation Plans, with expiration dates, is available on SEMA's website https://sema.dps.mo.gov/programs/mitigation_management.php under *Hazard Mitigation Plans: Approved and Expiration Dates*. A nationwide map of FEMA Approved Local Hazard Mitigation Plans is also available on this SEMA website. To obtain a copy of a Missouri Local Hazard Mitigation Plan, the MACOG website provides links to each of the individual RPC websites which in turn post the Local Hazard Mitigation Plans for download and/or viewing. The MACOG website link is available here: https://macog.org/regional-council-rpcs/. All of the Missouri Local Hazard Mitigation Plans are available on their respective RPC website or County website.

In addition to the county-level plans, multi-jurisdictional hazard mitigation plans have been prepared for Missouri's Electric Cooperatives and the regional areas of St. Louis and Kansas City, as described below:

- The Association of Missouri Electric Cooperatives (AMEC) worked in cooperation with the MACOG and the 19 RPCs to develop the 2012 Plan. A 2023 plan update is currently underway. The Northwest Missouri Regional Council of Governments (NWMORCOG) is the lead agency for plan development with each regional planning commission completing up to four local cooperative chapters for inclusion in the statewide plan.
- Since 2004, the five counties in eastern Missouri (Franklin, Jefferson, St. Charles and St. Louis Counties and the independent City of St. Louis) that make up the Missouri portion of the St. Louis region, and the 135 municipalities located within them, have collaborated as members of the East-West Gateway Council of Governments (EWG) to develop an All Hazard Mitigation Plan. The communities share common geographic, climatic and related risk factors that make them similarly susceptible to certain natural hazards.
- Since 2004, the Mid-American Regional Council (MARC)has worked with local officials in Jackson, Clay, Platte, Cass and Ray Counties and jurisdictions within those counties to prepare a Regional Multi-Hazard Mitigation Plan for the Kansas City metropolitan area that helps local governments, school districts, businesses, community groups and citizens with planning and mitigation efforts. For the 2020 Plan, nearly 60 communities, school districts, and fire/ambulance districts worked to update the Regional Hazard Mitigation Plan.
- In 2016 Jasper and Newton Counties developed and approved a bi-county multi-jurisdictional hazard mitigation plan. Both counties determined that a bi-county plan would best serve the region due to the geographic location of Joplin which is bisected by the county line. The plan was updated in 2021 and continued to build on the foundation of the previous plan, focusing on inter-county mitigation.

Figure 5.2. Local Mitigation Plan Status by County, July 2022



Source: SEMA Recovery Division, Mitigation Management

5.1.3. Process to Provide Local Support

Most jurisdictions require some form of assistance to develop and update their local hazard mitigation plans (FEMA requires that local plans be updated every five years, but plans may be updated more frequently if needed—e.g., after a major disaster). Since funding for planning purposes is generally minimal, and SEMA is unable to provide planning funds to every jurisdiction that requires a local hazard mitigation plan, technical assistance, training, and coordination with the RPCs are the primary methods that SEMA uses to provide planning support to local jurisdictions. Disaster declarations and the availability of post-disaster mitigation funds have provided further incentive to complete local plans.

Since local plans are required to be updated every five years, SEMA focuses resources on updating plans cyclically, prior to expiring. SEMA has developed planning guidance and plan outline documents and offers one-on-one technical assistance and training sessions, often in conjunction with FEMA. The FEMA *Local Mitigation Plan Review Guide* released in October 2011 and the *Local Mitigation Planning Handbook* released in March 2013 assist with local planning efforts and are available on SEMA's website: https://sema.dps.mo.gov/programs/mitigation_management.php under *Eligibility Planning Requirements*. The Local Mitigation Planning Guide has been updated (April, 2023) and is available on FEMA's website. Training sessions are also offered with communities when new Flood Insurance Rate Maps (FIRMs) are issued.

To facilitate the update process, SEMA works with the RPCs by providing updated State-level and FEMA guidance, county-level risk assessment results for all of the hazards profiled in the State Plan, and by hosting planning workshops. Sections 4.6.3 and 5.1.5 provide additional details about the workshops that have been

provided over the last three years.   SEMA also provides additional planning assistance through the services of a full-time mitigation planner specializing in local mitigation plans. Support for the update process will continue indefinitely to ensure that plans expiring in 2022, 2023, and beyond are fully supported and updated.

All counties in Missouri as of October 2018 have an approved local hazard mitigation plan. SEMA continues to encourage and applies on behalf of the local governments to update using Hazard Mitigation Assistance grants. SEMA encourages participation in multi-jurisdictional plans and is considering how to handle jurisdictions that chose not to participate in their county-level plans but are now interested in developing individual plans.

5.1.4. Funding

There are three primary sources of funds available to help local jurisdictions develop and update hazard mitigation plans. These sources are FEMA's HMGP and PDM planning grants and Building Resilient Infrastructure and Communities (BRIC) funding. Detailed information about these programs is available in Section 4.5 Funding Sources.

Hazard Mitigation Grant Program

Planning Applicability

Up to 7 percent of the HMGP funds set aside following a Presidential Disaster Declaration may be used to develop FEMA-approved mitigation plans.

SEMA Fund Administrator

Recovery Division, Mitigation Management Section, State Hazard Mitigation Officer

Missouri Local Hazard Mitigation Grant Program Planning Distributions

Table 5.1 shows the HMGP funds used to fund the local mitigation planning from Presidential disasters in 2002 through 2022. There were no HMGP funds available for local planning in 2004, 2005, 2010, or 2012.

Table 5.1. HMGP funds used for Local Planning 2002-2022

Year of Federal Declaration	Declaration Number	Federal 75% share
2002	DR 1403	$529,366
2002	DR 1412	$135,600
2003	DR 1463	$139,689
2006	DR 1635	$294,736
2007	DR 1676	$750,000
2007	DR 1708	$81,758
2007	DR 1736	$235,620
2008	DR 1749	$150,000
2009	DR 1809	$153,972
2009	DR 1822	$334,454
2009	DR 1847	$299,997
2011	DR 1980	$369,666
2011	DR 4012	$12,000
2013	DR 4144	$118,948
2014	DR 4200	$83,625

Year of Federal Declaration	Declaration Number	Federal 75% share
2015	DR 4238	$366,525
2016	DR 4250	$516,000
2017	DR 4317	$301,859
2019	DR 4435	$361,403
2020	DR 4490	$415,275
Total		**$5,650,493**

Source: State Emergency Management Agency, FEMA Hazard Mitigation Assistance (https://www.fema.gov/data-visualizations/hazard-mitigation-assistance-obligations)

*Pre-Disaster Mitigation Program

Planning Applicability

PDM grants can be used for mitigation plan development, upgrades, comprehensive reviews and updates. Recipients of PDM planning grants must produce FEMA-approved hazard mitigation plans.

SEMA Fund Administrator

Recovery Division, Mitigation Management Section, State Hazard Mitigation Officer

Missouri Local Pre-Disaster Mitigation Program Planning Distributions

PDM grants are also used for the development of local mitigation plans. In **Table 5.2** below, the PDM funds used for local planning for 2002, 2003, 2005, 2014, 2015, 2018, and 2019 total over $6.6 million. PDM funds from 2006-2013 and 2016-2017 have not been used for local planning, but for projects instead.

*Note, the Pre-Disaster Mitigation Program (PDM) has been replaced by Building Resilient Infrastructure and Communities grant program in 2020.

Table 5.2. PDM funds used for Local Planning 2002-2019

Year of PDM Funding	Federal 75% share
2002	$367,466
2003	$248,375
2005	$627,580*
2014	$299,843
2015	$250,000
2016	$575,000
2018	$171,090
2019	$425,292
Total	**$2,964,646**

Note: * The 2005 funds included State and Local Planning Source: State Emergency Management Agency

Flood Mitigation Assistance Program

Planning Applicability

FMA funding is available through the National Flood Insurance Fund (NFIF) for flood hazard mitigation projects, as well as plan development and is appropriated by Congress.

SEMA Fund Administrator

Recovery Division, Mitigation Management Section, State Hazard Mitigation Officer

Missouri Local Pre-Disaster Mitigation Program Planning Distributions

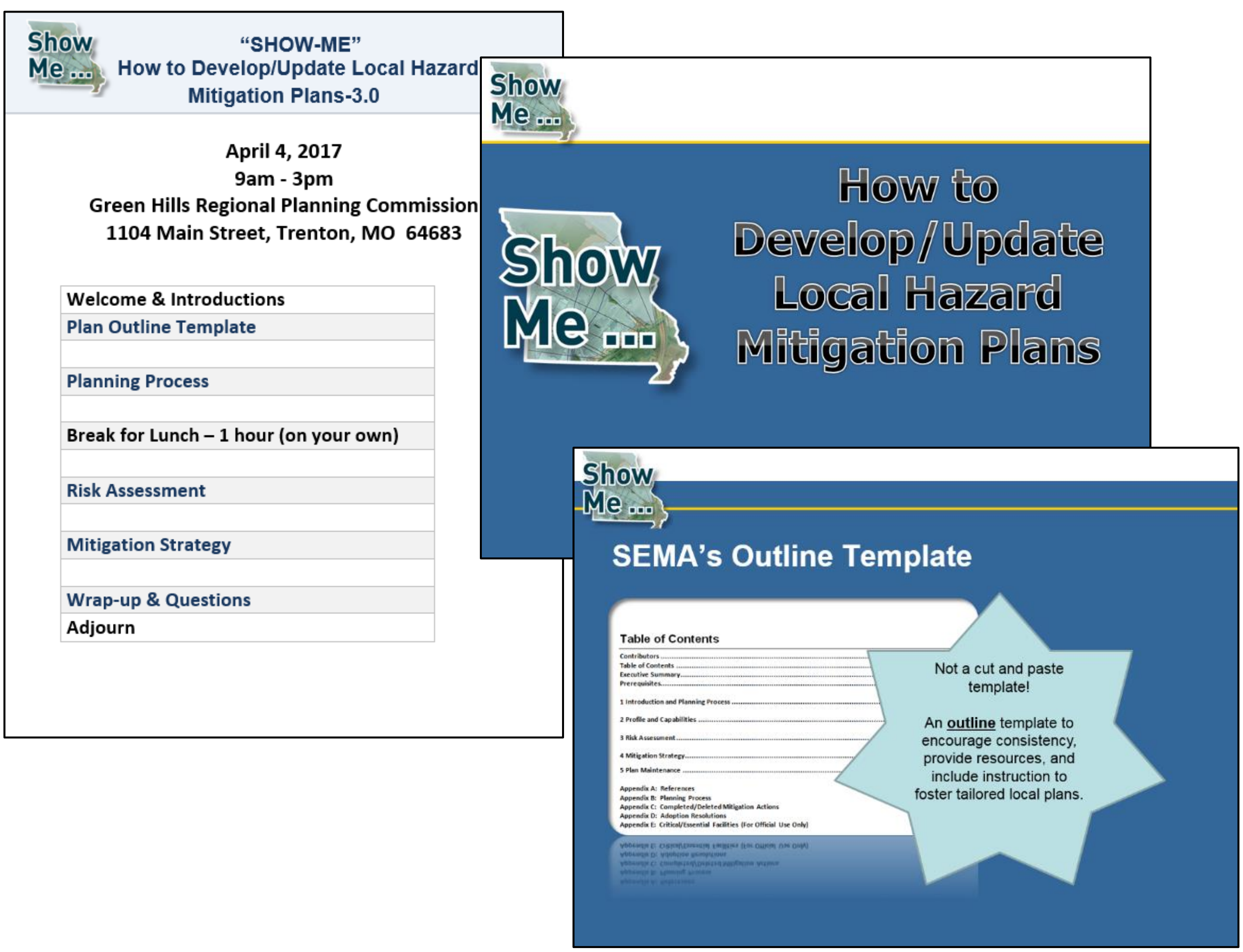
FMA funds have not been used for local planning in Missouri, but for projects instead.

5.1.5. Technical Assistance and Training

SEMA provides technical planning support to local jurisdictions through the Recovery Division, Mitigation Management Section. As discussed in Section 5.1.3 Process to Provide Local Support, SEMA contracted with the RPCs and provided them with guidance written by the State Hazard Mitigation Officer to develop mitigation plans for the local governments in their regions.

Since 2015, Local Hazard Mitigation Plan Development Training has been offered in three locations throughout the State to assist RPCs with the development of Local Hazard Mitigation Plans. This training is an in-person, 2-day workshop covering the fundamentals of mitigation planning requirements for communities to develop new or updated Local Mitigation Plans that address community priorities and needs and meet requirements established in 44 CFR 201.6. This workshop describes the SEMA developed plan outline template, the planning process, the requirements for stakeholder involvement, assessing risks and developing effective mitigation strategies (see **Figure 5.3**). In addition, SEMA's Mitigation Management Section provides program specific information related to federal/state mitigation policy, state mitigation priorities, program administration, funding sources, and project eligibility requirements.

Figure 5.3. Sample Local Hazard Mitigation Plan Development Training Agenda and Presentation



In 2015, SEMA created a hazard mitigation plan outline to use for local plans. This plan outline provides a framework and format for development of local hazard mitigation plan updates. It is organized with headings and subheadings to present meaningful information as well as ensure compliance with the local hazard mitigation planning requirements. The plan outline includes some sample text as well as instructions on the information that should be included under each heading and subheading. The plan outline also serves to provide useful resources and links where plan data may be researched and obtained.

The use of the plan outline will promote greater consistency among local plans, allowing information from the local plans to roll up to the State Plan more effectively as well as allow data from the State Plan to roll down to the local plans. This system will provide continuity of data and planning efforts which increases the success of meeting goals while also reducing the duplication of effort in creating both local and State Plan updates.

In 2016, SEMA developed planning meeting “kits” which included sample planning meeting agendas, minutes, sign-in sheets, PowerPoint presentations and more. These planning meeting kits have the capability to be modified and tailored to suit the needs of community planners. Both the planning kit and outline documents have been updated.

Instructional methodology for preparing the hazard risk assessments, as well as risk assessment results and mapping are offered through the update and revision of the State Hazard Mitigation Plan. This 2023 state plan update included vulnerability analyses for all 22 hazards. If a local community does not have a methodology to use for their local hazard vulnerability, then the state plan methodology is an option for them to use. Additionally, with the 2023 state plan update, an online web-application for accessible risk assessment data was developed. This web-application streamlines access for State and Local planners to the 2023 State Hazard Risk Assessment results/data and associated mapping. The web-application includes a Map Viewer with a legend or clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the State Plan for easy reference, search and query capabilities, zoom levels to County level data, and the capability to prepare and format downloadable PDF maps, as well as, Microsoft Excel data tables.

Since November 2007, staff support has also been available for local communities through SEMA’s full-time Lead Planner. This Lead Planner is available to provide technical assistance and to review the local plan documents in all stages of development. Planning information, including regulatory updates, are provided by the Lead Planner to the MACOG and RPCs.

With the dedicated Lead Planner, the overall effectiveness of the local plans has increased. The Lead Planner is able to give the local RPC planners ideas for specific hazards data and direct them to the risk assessment results and vulnerability analysis for their area, thus creating a more detailed local multi-hazard mitigation plan particularly for more vulnerable jurisdictions (i.e. highly populated communities).

5.1.6. Barriers to Local Mitigation Planning

Within the process of developing or updating, adopting and implementing FEMA-approved local hazard mitigation plans there may be barriers which hinder the local community from moving the process forward. **0** presents a summary of potential barriers utilizing the STAPLEE framework and a summary of SEMA Mitigation Management Section’s approach to addressing and removing these barriers in order to advance local mitigation planning.

Table 5.3. Barriers to Local Mitigation Planning and Approach to Remove

Barriers to Local Mitigation Planning	Summary of SEMA's Approach to Remove Barriers
Social: Perceived importance and/or community acceptance of mitigation planning	SEMA promotes the requirements and benefits of local mitigation planning through multiple planning workshops across the State, post-disaster coordination activities, publication of mitigation success stories, regular communication with MACOG and the 19 RPCs, and posting of outreach materials on the SEMA website.
Technical: Lack of resources to develop risk assessments	With the 2023 State Plan Update, a web-application for accessible risk assessment data was developed. This application removes a barrier for local mitigation planners to performing all the needed local Risk Assessments by providing default data developed for the State Plan which can be accessed online and is available in both a tabular and spatial mapping format.
Administrative: Lack of personnel to prepare the plan	In Section 5.1.5, SEMA provides the local planning community with training workshops; planning "kits" with meeting materials; a plan development outline with instructions; and a full-time Lead Planner to answer questions, provide instruction, and review plan documents. While SEMA does not provide personnel to prepare plans, numerous planning materials are provided to streamline the planning process for the local community.
Political: Lack of local champion to lead planning process	Since 2004, SEMA has partnered with the MACOG and the 19 RPCs, the Mid-American Regional Council (MARC), the East-West Gateway Council of Governments (EWG), the Springfield-Greene County Office of Emergency Management, and Missouri's Electric Cooperatives to assist with the development of multi-jurisdictional local hazard mitigation plans. As a result of these partnerships, every county and the Missouri electric cooperatives have approved hazard mitigation plans
Legal: Requirement for Mitigation Planning	Legal precedence for local mitigation planning is addressed in the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended by the Disaster Mitigation Act of 2000, requiring local governments to develop and adopt FEMA-approved hazard mitigation plans as a condition for receiving certain types of non-emergency disaster assistance.
Economic: Lack of available funding	As mentioned in Section 5.1.4, there are three primary sources of funds available to help local jurisdictions develop and update hazard mitigation plans, FEMA's HMGP, FMA, and BRIC. SEMA provides information on all FEMA HMA grant programs, including eligibility, application needs, and deadlines on their website: https://sema.dps.mo.gov/programs/mitigation_management.php SEMA encourages local governments to apply for FEMA planning grants, as well as, to participate in multi-jurisdictional plans to share the financial burden.
Environment	Although not required for local mitigation plans, with the 2023 State Plan update SEMA has addressed changing future conditions, including the effects of long-term changes in weather patterns and climate on the identified hazards. As local mitigation plans consider inclusion of changing future conditions in their update processes, SEMA and the information provided within the State Plan update will support this effort.

5.2. Local Plan Integration

Requirement §201.4(c)(4)(ii): [The section on the coordination of local mitigation planning must include a] description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the state mitigation plan.

Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

5.2.1. Review and Approval of Local Plans

The DMA 2000 (Section 322(b)) calls for each local plan to "describe actions to mitigate hazards, risks, and vulnerabilities identified under the plan and establish a strategy to implement those actions." FEMA expanded on these basic criteria and established specific requirements for local mitigation plans in *Local Mitigation Planning Policy Guide, April 2023*, and *Local Mitigation Planning Handbook*, March 2013. SEMA's hazard mitigation plan guidance dictates that local hazard mitigation plans be developed to meet all federal requirements, address the specific hazard mitigation needs of the applicable jurisdictions, and complement the Missouri State Hazard Mitigation Plan. The state plan is used as a reference for locals to refer to in plan development. To ensure that local hazard mitigation plans meet these established criteria, SEMA works closely with the RPCs and local jurisdictions.

Local hazard mitigation plans undergo a continuous review during development that involves state and local officials and concerned members of the applicable communities. This helps to ensure that plans develop smoothly and that the final plan is acceptable to the jurisdiction, its citizens, and the State. In 2004, SEMA reviewed all of the local plans before sending them on to FEMA for review and approval.

The state plan review process changed significantly in November 2007 with the addition of a full-time lead planner at SEMA that specializes in local mitigation planning. Plan reviews are completed by the full-time mitigation planner. These reviews are completed as quickly as possible in order to provide for sufficient time to complete any necessary revisions prior to submission to FEMA.

The current process used to review and approve both new and updated plans is outlined below:

- The submitting RPC submits the adopted plan with resolutions to SEMA.
- The SEMA mitigation planner works with the submitting jurisdiction or RPC to resolve any concerns as necessary and completes a formal review of the plan.
- After successful integration of the required plan elements the plan is approved by SEMA.
- SEMA sends the plan document to FEMA Region VII for approval.
- FEMA reviews and grants final approval (this determines the date of approval).
- SEMA notifies the submitting jurisdiction or RPC of final approval with a letter.

SEMA's goal is to complete local plan reviews within three weeks from the date of final plan receipt. During times of peak demand for review, plans are prioritized based on date of expiration for review in order to ensure that the expiration of plans is avoided.

Local mitigation projects and initiatives are based on the goals and objectives of local plans. However, it is understood that funding, situations, and priorities change. SEMA and FEMA allow jurisdictions the flexibility to add/subtract mitigation projects as priorities, due to funding and other changing circumstances. Changes may be made to the plan review process, if needed, to comply with FEMA's guidance for local plan updates.

5.2.2. Integrating the Local Plans with the State Plan

The process of integrating state and local mitigation planning began with state staff involvement and guidance in the local planning process. It is understood by all levels of government that the success of the Missouri mitigation program depends on the degree to which everyone works together toward the common goal of reducing future disasters in Missouri. This is accomplished by involving as many interested groups and individuals as possible in the planning process. State mitigation staff meet with the RPCs and jurisdictions as needed throughout the planning process. While there is no specific schedule for these meetings, they occur:

- During scheduled public meetings
- At the start of the planning process
- At the mid-point of plan completion
- At plan completion
- As requested by the RPC and/or affected jurisdiction

It is also widely acknowledged that the local plans can benefit from data in the state plan, and the state plan can benefit from data in local plans. For this 2023 plan update, the State Risk Management Team (SRMT) reviewed and summarized information from the local plans. This information included:

- Hazard identification and risk assessment
- Goals and objectives
- Local capabilities
- Mitigation initiatives

The process in 2023 involved reviewing all of the local community plans and capturing the information related to the four categories above in spreadsheets for further review and comparison purposes. (For more details on this process, and how the information was collected and incorporated, see Section 3.6 Assessing Vulnerability and Estimating Losses by Jurisdiction: Integration of Local Plans, Section 4.1 Hazard Mitigation Goals and Objectives, Section 4.2 Mitigation Actions, and Section 4.6 Local Capability Assessment). This information was used to reassess state hazard and capabilities priorities and the progress in statewide mitigation efforts. Specifically, SEMA is interested in:

- Adding initiatives that proved successful at the local level
- Researching development of mitigation initiatives that address local concerns
- Reviewing state initiatives to determine if they are meeting the overall mitigation needs of the State
- Changing or eliminating mitigation initiatives that have not produced anticipated results

Additionally, SEMA has conducted, or is in the process of conducting a series of resilience meetings where information on tracking and coordinating NFIP/Risk MAP/Mitigation actions is being provided to local communities.

As of September 2022, this state plan update is integrated with existing and updated information from 114* local hazard mitigation plans. New and updated plans will continue to be incorporated into the state plan during the next five-year update cycle due in 2028.

Note: 114 includes 113 local county plans, plus the City of St. Louis, that have been FEMA approved, updated, and/or expired.*

5.2.3. Successes and Challenges in Integration

This 2023 update reflects the successful integration of 107 updated local hazard mitigation plans, representing 103 county level plans; two regional plans representing a total of 9 counties; one multi-

jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. Over 1,500 incorporated cities, towns, and villages participated in the development of and updates to these local hazard mitigation plans. SEMA has streamlined the integration process by:

- Encouraging local governments to participate in multi-jurisdictional county-level plans has reduced the total number of plans that need to be reviewed and integrated into the State Plan and has brought communities together to focus on mitigation. A prime example, flooding problems do not stop at corporate boundaries and coordinated planning is necessary to tackle these hazard events.
- Providing guidance through the full-time lead mitigation planner, Local Hazard Mitigation Plan Development Training Workshops, and a standardized Hazard Mitigation Plan Outline.
- Providing technical support through Hazus-developed county level maps of the 100-year floodplain developed in the 2013 State Plan update to be used in local flood risk assessments which will help locals assess/reassess their potential flood risk. Moving forward, instructional methodology for preparing the hazard risk assessments, as well as the 2023 State Plan risk assessment results and mapping will be available through a web-application.
- Simplifying hazard data for 2023 State Plan by combining each hazard profile with the associated state risk assessment for ease in locating information for individual hazards, as well as, clarifying definitions of extent and severity to standardizing these terms and avoid future confusion at the local level.

There do, however, remain challenges with integration of local plans into the state plan. Going forward, SEMA will continue to try and resolve inconsistences with the local plans, as well as, the following challenges:

- Timing of local plan updates and approvals. Because of hazard mitigation assistance grant funding availability, the plans are cycled to expire in different years and thus some county-level plans were updated following the cut-off date for plan integration.
- Variations in hazard identification. The integration process revealed that the county-level plans did not include manmade hazards in their analysis, but rather focused on the natural hazards. In addition, only a limited number of local plans discussed levee failure as a hazard separate from flood; lightning as a hazard separate from thunderstorms; and land subsidence/sinkholes.
- Methods for local risk assessments. Local risk assessments use different methods and interpretations to determine vulnerability and use different measures to assess risk. Rankings were primarily described in terms of high, moderate, or low. However, in some instances, the overall ranking was done on a five-step scale ranging from high to moderate-high to moderate to low-moderate to low. For integration purposes, these five-step scales were adjusted as follows: high and mod-high rankings were summarized as high; moderate as moderate; and low and low-mod as low. In cases where overall vulnerability ranking information was not available, rankings were determined from the individual hazard probability and severity rankings.

More information about local plan integration can be found in Section 3.4 Integration of Local Plans: Vulnerability and Loss Estimates; Section 4.1 Hazard Mitigation Goals and Objectives, Section 4.2 Mitigation Actions, and Section 4.6 Local Capability Assessment.

5.3. Prioritizing Local Assistance

Requirement §201.4(c)(4)(iii): [The section on the coordination of local mitigation planning must include] criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs which should include:

-Consideration for communities with the highest risks,
-Repetitive loss properties, and
-Most intense development pressures.

Further that for non-planning grants, a principal criterion for prioritizing grants shall be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.

Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

This section describes the criteria Missouri uses to prioritize distribution of planning and project grants to communities and local jurisdictions. The criteria and process remain the same as was indicated in the previous State Hazard Mitigation Plans. SEMA, however, is constantly striving to improve the number of practical and fundable mitigation projects that are identified in local plans and funded by the State.

5.3.1. Federal Planning Grants

Federal and state funding for mitigation planning is limited and in some instances not available. The Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, and Building Resilient Infrastructure and Communities program are the primary sources of funding for mitigation planning. In the past, funding to meet the non-federal match requirement of these grants came from Missouri's general revenue and local sources (cash and in-kind). Future non-federal matches will need to come primarily from local sources; as State general revenue will no longer be available.

There are always more requests for financial assistance for mitigation planning funds than there are funds available. Funding for mitigation planning is based primarily on the availability of funds and whether the requesting jurisdiction has demonstrated the desire and ability to complete their plan as well as to follow through with the initiatives developed in the plan (which should not be dependent on the availability of state or federal funds). The expiration date of any current plan is also taken into consideration when evaluating the possibility of a plan update project.

As previously mentioned, following two presidentially declared disasters in 2002 (DR 1403 and DR 1412) and one in 2003 (DR 1463), SEMA had a limited amount of planning funds available. The decision was made to use these funds to help meet the local hazard mitigation planning requirement. Since these funds were not sufficient to develop all of the required plans, SEMA developed criteria to select counties for funding in every region of the State: relationship to major rivers, population, number of federal disaster declarations (past 25 years), participation in the National Flood Insurance Program, and past mitigation funding.

Over time, SEMA has developed a more sophisticated method of prioritizing funding. SEMA now uses the following list of questions to help guide the distribution of mitigation planning funds. These criteria evolved as funding levels and expiration dates shifted over time. The most effective strategies included the integration of community planning capacity, staggering of plans with Regional Planning Commissions in order to prevent overload, and providing funds directly to communities instead of RPCs where appropriate.

- Does the community meet the criteria for the applicable grant program (FMA, HMGP, BRIC)?

- Based on the State and local risk assessment, what is the susceptibility of the community to natural and manmade disasters?
- Based on presidential disaster declarations, how many times has the community experienced disasters and what was the resulting damage (community infrastructure as well as families and businesses)?
- How many disasters that did not receive presidential declarations affected the community and what was the resulting damage (community infrastructure as well as families and businesses)?
- Does the community participate in the National Flood Insurance Program? If so, how many insured, repetitive loss structures are in the community?
- Is the community an *economically disadvantaged* community or does it have special developmental pressures?
- Based on previous grant experiences (such as disaster grants, mitigation projects, other grants, etc.) what is the community's record of successful performance?
- Based on previous grant experiences with other state agencies (e.g., the Department of Economic Development Community Development Block Grant program) and the community's Regional Planning Commission/Council of Government, what is the community's record of successful performance?
- Has the community demonstrated the ability to form effective public-private hazard mitigation partnerships?
- Does the Community have a current plan which may expire without additional funding support?

5.3.2. Federal Project Grants

Federal and state funding for mitigation projects is also limited and thus, the State is required to prioritize proposed local mitigation projects. The Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, and Building Resilient Infrastructure and Communities program remain the primary sources of funding for mitigation projects. Funding to meet the non-federal match requirement of these grants can come from U.S. Department of Housing and Urban Development (HUD) Community Development Block Grants (CDBG) and mostly from the local jurisdictions. As state general revenue is no longer available, future matching funds will have to come primarily from local sources. Ideally, all communities will participate in some form of mitigation; however, due to differences in local capabilities and priorities, including the status of local mitigation plans, the degree of participation varies greatly from community to community.

In evaluating mitigation projects that have been submitted for review and possible approval, SEMA considers several factors, which include, but are not limited to, the following:

- The specific requirements and/or restrictions placed on the projects by the funding source
- There will always be more requests for mitigation funds than there will be available funds
- Federal and state funding for mitigation projects will be limited and in some instances, may not be available
- Whenever possible, local jurisdictions should develop mitigation projects and initiatives that can be funded locally
- Local jurisdictions should actively pursue public-private partnerships, where appropriate, to achieve desired mitigation goals
- The requested mitigation project should complement the goals and objectives of the State and local mitigation strategy

- With the implementation of Risk MAP, the mapped areas of mitigation interest (AoMI), and the tracking of mitigation actions, SEMA prioritizes projects that are identified within FEMA Region VII's Regional Action Tracker (or as a mitigation action in the hazard mitigation plan).

When determining which communities will receive project grants, SEMA considers the basic criteria for assistance awards established by the Disaster Mitigation Act of 2000 (Section 203(g)):

- The extent and nature of the hazards to be mitigated
- The degree of commitment of the local government to reduce damages from future natural disasters
- The degree of commitment of the local government to support the hazard mitigation measures to be carried out using the technical and financial assistance
- The extent to which the hazard mitigation measures to be carried out using the technical and financial assistance contribute to established state/local mitigation goals and priorities
- The extent to which prioritized, cost-effective mitigation activities that produce meaningful and definable outcomes are clearly identified
- The extent to which the activities above are consistent with the local mitigation plan
- The opportunity to fund activities that maximize net benefits to society
- The extent to which assistance will fund activities in small and impoverished communities

Missouri's highest project priorities consider hazards, vulnerability, and capabilities. Flood buyout projects (especially for repetitive and severe repetitive loss properties), and other flood mitigation, and structural projects to protect essential infrastructure are the first priority. Projects to protect individuals from tornadoes and high wind rank second, followed by projects to reduce losses from earthquakes.

Specifically, SEMA uses the following list of questions to help guide the distribution of mitigation project funds:

- What is the hazard to be mitigated?
- Does the applicant have a FEMA-approved mitigation plan?
- Does the project complement state and local mitigation goals and objectives identified in the mitigation plans?
- Is the hazard being mitigated a priority hazard in the applicant's mitigation plan?
- Is the project cost-effective based on FEMA's benefit-cost analysis module?
- Does the project have the potential to substantially reduce the risk of future damage, hardship, loss, or suffering that may result from a major disaster?
- Does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties?
- In the past, what mitigation efforts were undertaken by the applicant using local funds and initiatives and what were the outcomes?
- What is the applicant's disaster history?
- Are sufficient mitigation funds available to complete the project?
- Does the applicant have sufficient funds (if other funds are not available) to meet the local share of the project?
- Does the applicant have the capabilities to complete the project as submitted?
- Does the project independently solve a problem?
- Does the project have the potential to have a larger impact on the local and state mitigation program than other submitted projects?
- Does the project have any negative impacts on neighboring communities?

When funding comes from the HMGP (post-disaster funding), priority is given to mitigation projects related to the hazard that necessitated the disaster declaration and those jurisdictions included in the disaster declaration.

Additional information about the process SEMA uses to evaluate and prioritize mitigation actions and determine cost-effectiveness is available in **Section 7.2.1** Process Used to Evaluate and Prioritize Mitigation Actions, **Section 7.2.2** Eligibility Criteria for Multi-Hazard Mitigation Projects, **Section 7.2.3** Eligibility Criteria by Mitigation Project Type, and **Section 7.2.4** Pre-Project Determination of Cost-Effectiveness of Mitigation Measures.

5.3.3. *Small and Impoverished Communities

44 CFR 201.2 establishes the following definition for small and impoverished communities:

> *"Small and impoverished communities means a community of 3,000 or fewer individuals that is identified by the State as a rural community, and is not a remote area within the corporate boundaries of a larger city; is economically disadvantaged, by having an average per capita annual income of residents not exceeding 80 percent of national, per capita income, based on best available data; the local unemployment rate exceeds by one percentage point or more, the most recently reported, average yearly national unemployment rate; and any other factors identified in the state plan in which the community is located."*

*Small and impoverished (synonymous) is now referred to as Economically Disadvantage Rural Communities.

Hazard Mitigation Grant Program

In regard to the plan requirement for HMGP project funds, the FEMA regional administrators may waive this requirement for small and impoverished communities. In these cases, a plan must be completed within 12 months of the award of the project grant. This process is to be used judiciously and should not be viewed as the normal sequence of the planning process.

Building Resilient Infrastructure and Communities Grant Program

Economically Disadvantaged Rural Communities (EDRC) are eligible for an increase in funding up to 90% federal cost share/10% non-federal cost share. Economically disadvantaged rural communities are communities of 3,000 or fewer individuals identified by the applicant, with residents having an average per capita annual income not exceeding 80% of the national per capita income, based on best available data.

5.3.4. Non-Federal Planning and Project Grants

Currently, SEMA's Mitigation Management Section neither manages nor disburses funds for non-federal planning or project grants.

6 PLAN MAINTENANCE PROCESS

6.1. Monitoring, Evaluating, and Updating the Plan

Requirement §201.4(c)(5)(i): [The standard state plan maintenance process must include an] established method and schedule for monitoring, evaluating, and updating the plan.

Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

As described in detail in Section 2, this update to the Missouri State Hazard Mitigation Plan is the result of the combined efforts of members of the State Risk Management Team (SRMT) which is composed of state, federal, local, and voluntary agency representatives. For a detailed listing of agencies represented on the SRMT, see **Section 2.1.2**.

Hazard mitigation planning is a continuous and ongoing process. Policies and procedures established in this plan reflect the current emergency management and hazard mitigation philosophy at both the state and national level. Changes in hazard mitigation programs and/or priorities, including changes in legislation and available funding, may necessitate modifications to this plan. A major disaster could also prompt modifications to this plan.

6.1.1. Plan Maintenance Process - Responsible Agency and Schedule

The Mitigation Management Section of the Recovery Division within SEMA is the lead group responsible for developing, monitoring, and updating the State Hazard Mitigation Plan. Meetings of the SRMT are scheduled by the Mitigation Management Section, as needed, to review and update this plan. Moving forward, these meetings are to be conducted at a minimum:

- In the event of a major disaster and/or upon receiving a Presidential Disaster Declaration, if needed/warranted
- As part of the State's hazard mitigation plan review/update every five years or as required
- When required/needed due to changes in federal/state regulations and/or legislation that impact the hazard mitigation program

In addition to the update requirements mentioned above, annually SEMA conducts an in-house review and update in order to assess the plan on a more regular basis. This review, done in conjunction with the development of SEMA's annual threat and hazard identification and risk assessment (THIRA), continues to allow the State to direct its priorities in the appropriate manner before disasters occur.

The following SEMA branches and other state agencies and departments participate in the development, review, and update of the state plan:

- SEMA's Recovery Division (Mitigation Management, Floodplain Management, and Public Assistance, Floodplain Engineering and Mapping Section)
- SEMA's Preparedness Division (Emergency Human Services, Training and Exercises, Missouri Emergency Response Commission, Radiological Emergency Preparedness Program, All-Hazard Planning Program, Medical Countermeasures Program, and Earthquake Program)
- SEMA's Response Division (Statewide Regional Coordinators, Readiness Section, and Logistics and Resources Section)

- SEMA's Fiscal Division (Emergency Management Performance Grant Section and Fiscal Administration Section)
- Members of the SRMT
- Other SEMA branches and/or state agencies and departments that may be asked to assist in the review of this plan based on legislative changes, FEMA policy changes, or State priorities affecting the state hazard mitigation program

Representatives from the various agencies and departments on the SRMT are responsible for reviewing the plan, providing input and suggesting changes to the plan based on the mitigation initiatives being undertaken by their respective organizations.

During updates, state agencies:

- Review the risk assessment and revise if necessary
- Review the vulnerability assessment and loss estimates and revise if necessary
- Review goals and objectives and revise if necessary
- Review hazard mitigation projects and initiatives to ensure there are no potential conflicts with ongoing agency initiatives
- Review hazard mitigation projects and initiatives to ensure they complement the statewide mitigation strategy
- Review existing state/federal programs to ensure that the state is taking full advantage of possible funding sources in its implementation of the State hazard mitigation program

A review of plan goals and objectives is emphasized as part of the regular plan review process. The review is in conjunction with the review and approval process of local hazard mitigation plans. This helps to ensure that the state and local hazard mitigation plans complement each other and that both state and local governments are working together to accomplish Missouri's mitigation goals. Additionally, proposed mitigation projects are reviewed to determine how they help state and local governments meet their established goals and objectives.

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized. Evaluation of progress can further be achieved by monitoring changes in vulnerabilities identified in the plan.

Public involvement in the hazard mitigation process is accomplished through open public meetings as part of the development and review of local hazard mitigation plans. This process began when the Regional Planning Commissions got involved with local mitigation planning meetings in 2004 and continues as local mitigation plans are developed and updated. State and local representatives participate in these meetings and public input is sought and taken into consideration in developing mitigation priorities. Additionally, the SRMT consists of a broad range of stakeholders from various sectors, agencies, and organizations.

6.1.2. 2023 Plan Update

For this update to the Missouri State Hazard Mitigation Plan, the previously approved plan maintenance process was followed and evaluated. The SRMT determined that the elements and processes originally proposed to monitor, evaluate, and update the plan were effective. With 6 Presidential Disaster Declarations in a 5-year period since the 2018 Mitigation Plan Update, the State again capitalized on

post-disaster coordination activities with other state and federal agencies to incorporate monitoring and evaluation activities for the Hazard Mitigation Plan.

As part of the disaster declaration process the State Emergency Operations Center was activated with each declaration. The members of the SRMT that participated in the response and recovery of those disasters came together to discuss implementation of the mitigation strategy as additional post-disaster mitigation funds became available.

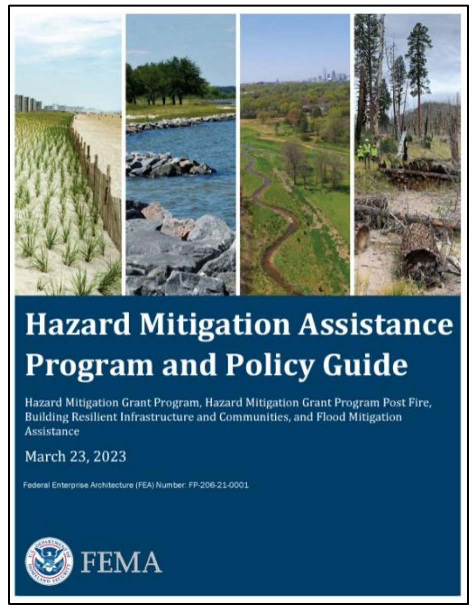
6.2. Monitoring Progress of Mitigation Activities

Requirement §201.4(c)(5)(ii): [The standard state plan maintenance process must include a] system for monitoring implementation of mitigation measures and project closeouts.

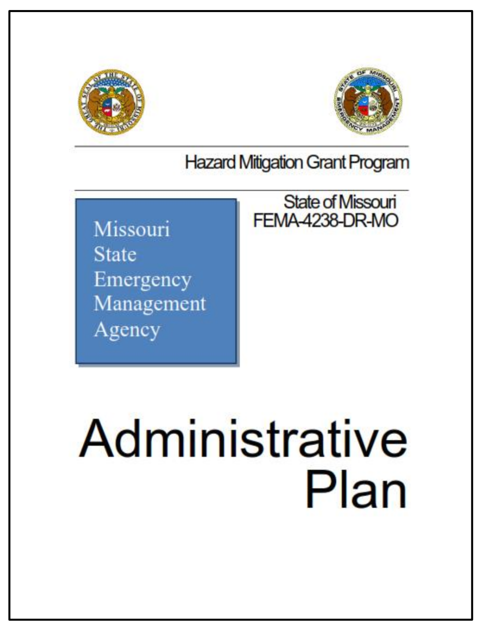
Requirement §201.4(c)(5)(iii): [The standard state plan maintenance process must include a] system for reviewing progress on achieving goals as well as activities and projects identified in the mitigation strategy.

6.2.1. Monitoring Implementation of Mitigation Measures Funded by FEMA

The State of Missouri ensures all Hazard Mitigation Assistance Program and Policy Guide (HMA) grants are implemented in accordance with current FEMA guidance. The most current FEMA guidance is the March 23, 2023 *Hazard Mitigation Assistance Program and Policy Guidance: Hazard Mitigation Grant Program, Hazard Mitigation Grant Program Post Fire, Building Resilient Infrastructure and Communities, and Flood Mitigation Assistance.*



The most current Administrative Plan, approved by FEMA, is the January 4, 2023 Administrative Plan. The Administrative Plan provides details on how the State monitors' implementation of mitigation measures and conducts project closeouts for the Hazard Mitigation Grant Program (HMGP). Although not all Hazard Mitigation Assistance Grants require a detailed State Administrative Plan, the State applies the basic monitoring and closeout procedures set out in the HMGP Administrative Plan consistently in the other applicable HMA programs where the State serves as grantee. This section includes a description of the current state monitoring system and modifications to the system identified during the 2023 plan update.



Mitigation Measures Monitoring System

The following paragraphs detail how the State tracks the implementation of mitigation actions and project closeouts.

Project Management and Responsible Agency

The State Emergency Management Agency is the recipient for project management and accountability of funds in accordance with 2 CFR Part 200. Approved applicants are considered subrecipients and are accountable to the recipient for funds awarded them.

Upon notification from FEMA that a project has been approved and is eligible for funding, the SHMO will notify the subrecipient and will arrange a meeting to provide the subrecipient with appropriate information on regulatory program requirements, State policy and

grant management in accordance with 2 CFR Part 200. Materials provided to the subrecipient, dependent on the type of project, may include:

- For tornado safe room projects, a *Hazard Mitigation Community Safe Room Project Administration Guidebook*. It will provide the policy and procedures specific to the type of project. For all other projects, guidebooks will be provided that are specific to the project.
- For buyout projects, *A Local Officials Guide to Managing a Voluntary Buyout*. It will provide the policy and procedures specific to the type of project.
- 2 CFR, Part 200 including OMB Circulars A-87 (as relocated to 2 CFR, Part 225), A-122 (as relocated to 2 CFR Part 230), A-133, and/or other applicable circulars.
  Example procurement, financial, etc. documentation.

Technical Assistance and Project Monitoring

SEMA (as recipient) recognizes their regulatory responsibilities for all HMA grants: The State, serving as recipient, has primary responsibility for project management and accountability of funds as indicated in 2 CFR Part 200. The State is responsible for ensuring that subrecipients meet all program and administrative requirements.

SEMA is committed to monitoring and providing technical assistance to all eligible and funded subrecipients. The SHMO, project manager, and/or technical support staff will provide materials and support for subrecipient meetings to ensure the policies and procedures are explained correctly. Numerous worksheets, financial forms, and targeted guidebooks for local officials (e.g., the Mitigation Planning Workshop for Local Governments and the All-Hazard Mitigation Planning Guidebook for Communities) have been developed by SEMA and have proven successful. SEMA also directs local governments to locate FEMA's Local Mitigation Planning Handbook and Review Guide, as well as, multiple hazard data resource websites.

To track mitigation projects from initiation to closeout, a project tracking spreadsheet is used that includes the following information:

- Subrecipient name
- Project name
- Grant amount
- Percent expended
- Percent completed
- Grant end date
- Completion description (by project task and percent complete)

A system to track each individual grant process completion has been developed and is tied to steps associated with specific project types. **Table 6.1** shows an example for a buyout project and how a percent is tied to a specific action completed.

Table 6.1. Project Tracking System—Buyout Example

Buyout	Percent Complete of the Project Process
Buyout Policy	5%
Voluntary Agreements	10%

Appraisals Contracted	15%
Appraisals Completed	25%
Title Search Completed	30%
Properties Closed	40%
Asbestos Determination	50%
Demolition Contracted	65%
Demolition Completed	80%
Final Invoices Paid	100%

A SEMA Mitigation Management Staff Member will offer assistance for the first closing of a buyout project to complete the necessary FEMA forms (e.g., Voluntary/ Uniform Relocation Act, Duplication of Benefits, Closing Statement).

Site visits, telephone conversations, e-mails, and facsimiles remain the best communication tools for the buyout program and any other mitigation project. Past mitigation successes reflect this; thus, SEMA is confident these mechanisms ensure subrecipients success in administering the HMA grants within federal and state regulations and policies. SEMA requires monthly progress reports (instead of quarterly) from subrecipients so that issues with implementation can be identified and handled in a timely manner.

A modified Standard Form 270, Request for Advance or Reimbursement, is used by SEMA for processing fund requests. General principles for processing Request for Funds (RFF) forms are as follows:

- Verify the RFF contains the original signature and is signed by the authorized signor.
- Verify spreadsheet columns are correct and check the mathematical accuracy.
- Check for supporting documentation (property list, invoices etc.).
- If a buyout project, verify all properties requested to be funded have received duplication of benefit information and SHPO clearance. Ensure other environmental compliance measures have been met if applicable to the RFF.
- Enter amounts requested on tracking spreadsheet to ensure the subrecipient does not receive more than the amount awarded.
- Forward RFF to SEMA's Fiscal Branch for processing.
- Copy all documents to project file.

As a general rule, only 50 percent of project management funds will be released prior to project closeout. Planning projects will be paid in phases of project completion, with a percentage withheld pending FEMA's approval of the mitigation plan. For construction projects, only 95 percent of the total project management funds will be reimbursed prior to completion of the construction.

Cost Overruns

Immediately upon recognition that an original scope of work approved and funded cannot be accomplished with the grant funds allocated, the subrecipient must submit a request for additional funds with appropriate justification along with a recalculated Benefit Cost Analysis, if applicable. Upon receipt, the State will review the documents and make a determination. If the request is justifiable and funding is still available, the State will forward the request with its recommendation to the FEMA Regional Administrator. If the request is not justifiable the State will deny the request. In no case will the total amount obligated to the State exceed the specific the funding limits set forth in 44 CFR 206.432(b).

For purposes of the mitigation buyout program, cost overruns are defined to be additional funds necessary to complete the acquisition of the target area defined in the original HMGP application submitted to FEMA for funding. Cost estimates for individual structure/lots on applications can be somewhat volatile. Property closings resulting in an overrun based on the estimate that can be offset by property closings resulting in a net under-run are not considered cost overruns for this purpose and thus do not need FEMA approval as outlined in 44 CFR 206.432(b).

Any properties “added” to the property list after initial submission to FEMA would be considered a change in scope and will require SEMA and FEMA approval. No changes can be made to the property list after the application period has passed and the application has been approved by FEMA. In addition, adjustments to budget line items based on the Buyout Application do not need FEMA approval.

For tornado safe room projects, cost overruns are defined to be additional funds necessary to complete the design and construction of the safe room to FEMA Publication 361 standards. Construction costs in materials continue to rise at indeterminate times. The additional costs may be offset by cost under-runs in other services. The same holds true for all other mitigation construction projects.

Appeals

All subrecipient appeals to FEMA decisions are administered in accordance with implementing program regulations.

A subrecipient may appeal any decision regarding projects submitted for HMA funding. The appeal must be submitted in writing and contain sufficient documentation to support the subrecipient’s position. The appeal must specify the monetary figure in dispute and the provisions in Federal law, regulation, or policy with which the appellant believes the initial action is inconsistent. The appeal must reach the Recipient within 60 days from the date the subrecipient was notified of denial of funding.

On behalf of the subrecipient, the State may appeal any FEMA denial for Federal assistance. Within 60 days of the date of the receipt of the appeal from the subrecipient, the State will review the material submitted, make additions if necessary, and forward the appeal with a written recommendation to the FEMA Region VII Administrator.

Quarterly Reports

Quarterly Reports based on the federal fiscal year will be provided to the FEMA Region VII Administrator as required by regulation within 30 days of the quarter end date.

Any problems or circumstances affecting completion dates, scope of work, or project costs which would cause non-compliance with FEMA approved grant conditions shall be described in a letter to FEMA requesting an extension, change in scope of work, etc.

Environmental, Historic, and Floodplain Management Reviews

All projects that involve the floodplain will be coordinated with SEMA’s Recovery Division, Floodplain Management Section staff. In addition, the SEMA Mitigation Management Section will coordinate with other state agencies as appropriate. This coordination will depend on the type of project as required by 44 CFR. For example, project descriptions will be provided to the Department of Natural Resources State Historic Preservation Office for review of potential historic and archeological issues, the Department of Conservation for potential fish and wildlife impacts. In addition, SEMA may use the services of the Department of Transportation for more complex environmental reviews.

Review

Upon completion of a hazard mitigation grant project, the SHMO, Hazard Mitigation Specialist, or other SEMA staff will conduct a closeout site visit to review all files (or a representative sample) and the documents pertaining to the use of 404 and State General Revenue funds when applicable. In addition, all procurement files and contracts to third parties will be reviewed. Worksheets have been created to aid in the closeout review.

All reports generated at the closeout site visit are compared with Requests for Funds submitted throughout the duration of the project. Any significant findings are reported to the SHMO for final determination in corrective action. Corrective Action notices will be sent to subrecipients and another site visit will be conducted (if necessary) prior to the release of remaining project funds.

Project Closeout

Upon completion of a HMA grant project, the program manager and/or hazard mitigation grant auditor conducts a closeout site visit to review all files (or a representative sample) and all documents pertaining to the use of HMA grant and state general revenue funds. In addition, all procurement files and contracts to third parties are reviewed. Worksheets have been created to aid in the closeout review.

All reports generated at the closeout site visit are compared with Requests for Funds submitted throughout the duration of the program. Any significant findings are reported to the SHMO for final determination in corrective action. If necessary, Corrective Action notices are sent to subrecipients, and another site visit may be conducted if deemed necessary prior to the release of remaining project funds. Closeout reports will be submitted for each subrecipient upon expiration of the grant. The closeout report will summarize the following:

- Grant Application and Approval Award
- Procurement
- Environmental Compliance, if necessary
- Final Scope of Work Completed (i.e. if a buyout project, the final list of properties acquired)
- Verification of Project Monitoring and Correspondence
- Summary of Costs Incurred and Reimbursement Received
- Pictures of work completed
- GIS coordinates of the project site

Closeout reports will generally be submitted 90 days after notification by a quarterly report that the project has been completed. Note: delays could occur due to extenuating circumstances, such as another disaster declaration.

Audit Requirements

2 CFR Subpart F Audit Requirements: OMB A-133, and the Single Audit Act of 1984, as amended in 1996 all require subrecipients expending $750,000 or more in Federal assistance to have an audit conducted in accordance with the Single Audit Act. Copies of such reports, if applicable, will be requested.

All general audit requirements in 2 CFR Part 200 (Subpart F) and in accordance with 44 CFR 206.437(b)(4)(xii) will be adhered to by SEMA as well as subrecipients expending FEMA hazard mitigation grant awards.

2023 Plan Update

As part of the update to the Missouri State Hazard Mitigation Plan, the previously approved plan's monitoring system for implementation of mitigation measures and project closeout was evaluated. It was determined that the monitoring system described herein to track the initiation, status, and closeout of mitigation activities was taken largely from the former effective Administrative Plan. Therefore, the changes to this section involved incorporating changes that were integrated into the current approved Administrative Plan. The SHMO continues to have primary responsibility for continued management and maintenance of the monitoring system. Future reviews will be conducted in accordance with the process and schedules established for the plan maintenance process.

The review of mitigation actions implemented since the last plan update revealed that the mitigation actions were implemented as planned. A description of mitigation actions implemented since the 2018 State Hazard Mitigation Plan development is in **Section 4.2.5** Review and Progress of Mitigation Actions. **Table 4.7** in that section provides a summary of mitigation actions implemented and estimated funding amounts for 2002–2021. This table demonstrates that the actions implemented fall within the overall State priorities for mitigation.

6.2.2. Monitoring Implementation of Mitigation Measures Not Funded by FEMA

Currently, SEMA's Mitigation Management Section neither manages nor disburses funds for non-federal planning or project grants.

6.2.3. Monitoring Progress for Mitigation Goals, Objectives, and Activities

A review and update of the State's system for conducting a progress review of mitigation goals, objectives, and actions is also conducted as part of the plan maintenance process. This section includes a description of the State's process for monitoring the progress of mitigation goals, objectives, and actions and any modifications to the system identified during the 2023 plan update.

Mitigation Progress Review System

In order for any program to remain effective, the goals and objectives of that program must be reviewed periodically. That review should answer, at a minimum, the following questions:

- Are the established goals and objectives realistic? (Take into consideration available funding, staffing, state/local capabilities, and the overall state mitigation strategy.)
- Has the State clearly explained the overall mitigation strategy to local governments?
- Are proposed mitigation projects evaluated based on how they help the State and/or local government meet their overall mitigation goals and objectives?
- How have approved mitigation projects complemented existing state and/or local government mitigation goals and objectives?
- Have completed mitigation projects generated the anticipated cost avoidance or other disaster reduction result?

A thorough and realistic evaluation of the benefits of a mitigation project may be delayed until the area of the project is impacted by another disaster. The lack of realized benefits from a completed mitigation project may result in the disapproval or modification of similar projects in the future. At the same time, mitigation projects that have proven their worth may be repeated in other areas of the State.

Based on the results of the review/evaluation of mitigation progress described above, the State may need to adjust its goals and objectives to meet the current and future mitigation needs of the State and local governments. The Mitigation Management Section provides the SEMA Director status updates as needed.

2023 Plan Update

For this update to the Missouri State Hazard Mitigation Plan, the system for reviewing progress on achieving goals as well as progress of mitigation activities was evaluated. It was determined that the process stated herein to monitor progress was effective. As part of the 2023 plan update process, the goals and objectives outlined in the 2018 plan were reviewed to determine if they still address current and anticipated future conditions. This was accomplished during planning meeting #1 and during focused meetings with SEMA mitigation staff. The SRMT also evaluated the goals and objectives based on following:

- The updated 2023 statewide risk assessment, including changes in development, recent disasters, and analysis of local risk assessments.
- Assessment of changes and challenges in state and local capabilities since the 2018 plan.
- Analysis of the similarities and differences of the state mitigation plan goals with local mitigation plan goals and objectives.
- Identification of achieved mitigation objectives from the 2018 plan.

This review of the 2018 goals and objectives and modifications to the review process are described in more detail in **Section 4.1.2** Process for Identifying, Reviewing, and Updating State Goals and Objectives.

The status of each mitigation action was also evaluated to ensure that the State is making progress with its overall mitigation strategy. Conducting a comprehensive review of state goals and objectives in conjunction with identified mitigation actions helps ensure consistency with Missouri's overall mitigation goals.

Progress of identified mitigation actions is measured based on the following variables:

- The number of projects implemented over time
- The successful disbursement of mitigation grant funds over time
- The disaster losses avoided over time (given a post-disaster event)
- Plans, partnerships, and outreach developed over time

There has been significant progress made in the implementation of the State's hazard mitigation strategy since the previous plan update. This has included the completion of 44 safe room projects for a total of $58 million, 30 flood buyout projects for a total of $9.8 million, 21 warning systems projects for a total of $0.7 million, two utility protective measure projects, four infrastructure protective measure projects, and six generator projects at a total of $3.2 million. SEMA has also continued to coordinate with local jurisdictions, to ensure that local hazard mitigation plans are updated and in effect throughout the State. Technical assistance and funding have been provided where needed.

6.2.4. Agency Roles and Responsibilities

In addition to the duties of the SRMT, SEMA implements and updates the State Mitigation Plan and administers the HMA grant programs using the following positions:

State Hazard Mitigation Officer

The Governor's Authorized Representative (GAR) designates the SHMO. Pursuant to 44 CFR 206.437(b)(2), the GAR identifies the SHMO. At SEMA, the SHMO has overall management responsibility for the mitigation program and is the State official who is ultimately responsible for ensuring that the State properly carries out its Section 404 responsibilities subsequent to a presidential disaster declaration. In this regard, the SHMO monitors and oversees the activities of the Mitigation Specialists, other staff support and the State Risk Management Team. The SHMO coordinates with other SEMA staff and other state executive departments as necessary to ensure the program work required of the State is accomplished to fairly and effectively deliver all Hazard Mitigation Assistance grants to eligible subrecipients.

Deputy State Hazard Mitigation Officer

The Deputy SHMO reports directly to the SHMO with empowerment to act, in their behalf, should a substitution be necessary. On a daily basis, the Deputy SHMO assists the SHMO in organizing, coordinating, implementing and administering hazard mitigation projects, including planning projects, and the promotion, direction and evaluation of mitigation issues.

Hazard Mitigation Specialists

Hazard Mitigation Specialists serve two primary roles: (1) to complete the necessary program work required of the State to deliver the Hazard Mitigation Grant Program to eligible subgrantees; and (2) to provide technical assistance to locals as they develop their hazard mitigation plans.

Mitigation Management Team(s)

At various times, for various lengths of time (depending on the workload, complexity, and duration of the plans and projects for the multiple disasters covered by this plan), a management team(s) of the following (full, temp and/or part-time) positions will be filled by SEMA staff, and/or contracted consulting staff, and/or services:

- Hazard Mitigation Specialists
- Accounting Specialists
- Emergency Management Officers/Specialists
- Environmental Specialists
- Planners
- Engineers
- Surveyors
- Appraisers
- Real Estate Specialists
- IT/GIS Specialists/Technicians
- Legal Specialists
- Admin Executives/Office Support Assistants
- Other technical and/or fiscal/clerical/admin specialists as needed

The team(s) will assist the SHMO to manage (organize, promote, coordinate, assist, train, research, analyze, apply, implement, administer, direct, review, prepare and submit etc.) hazard mitigation plans,

Benefit-Cost Analyses, projects, issues, outreach, evaluations, Closeout Reports, Success Stories and Loss Avoided Studies, etc. The team(s) continue to support SEMA's program work/activities required to perfect, preserve and deliver the Hazard Mitigation Grant Program (HMGP) assistance provided to eligible subrecipient.

Responsibilities of the SHMO, hazard mitigation staff, and others include, but are not limited to:

- Ensuring the Missouri Hazard Mitigation Grant Program Administrative Plan is updated, outlining how the State will administer the Hazard Mitigation Grant Program and implementing it during a disaster.
- Ensuring that the Missouri State Hazard Mitigation Plan is active, identifying potential hazard mitigation projects, and establishing priorities among those projects.
- Coordinating with the federal hazard mitigation officer in determining the composition of the interagency hazard mitigation team or hazard mitigation survey team when one is established (and its schedule of activities), in estimating the amount of FEMA money available for the Section 404 program, and in administering the program, including submitting required reports to FEMA (all coordination will take into consideration the priorities and procedures as set by the Missouri State Hazard Mitigation Plan).
- Coordinating with state and federal officials to ensure that they understand the involvement of the hazard mitigation effort in the Public Assistance program.
- Ensuring that potential applicants are notified of the mitigation grant programs and receiving the assistance to which they are entitled.
- Developing and implementing a process for identifying potential hazard mitigation projects and for setting priorities among those projects.
- Ensuring that a proper initial application and benefit-cost analysis, and any necessary supplemental applications, including SF-425's, are prepared, coordinated, and submitted in a timely fashion to the FEMA regional administrator.
- Ensuring that technical assistance is provided to potential applicants and/or eligible subrecipients in developing and submitting applications and benefit-cost analyses and in managing and completing approved mitigation projects, to include site visits as necessary.
- Ensuring development of a system to monitor the status of approved projects, for processing extension requests and appeals, and for closing out completed projects.
- Ensuring that adequate procedures are developed for the distribution of financial assistance to eligible subrecipients.
- Ensuring that a system exists to monitor subrecipient accounting systems and compliance with 44 CFR parts 13 and 14.
- Ensuring a computer management system and/or files are maintained for hazard mitigation activities and products.
- Ensuring that appropriate state agencies and divisions are involved as necessary with the hazard mitigation process to include coordination with the SEMA Floodplain Management Section.
- Ensuring that the required performance reports, such as quarterly progress reports, closeout reports, success stories and loss avoidance studies are prepared and submitted in a timely manner to FEMA.

Other SEMA Staff Involvement

The SEMA director (GAR) and deputy director provide overall guidance, direction, and support for the mitigation program.

The Recovery Division Manager provides direct supervision of, as well as general guidance, direction, and support for the SHMO who manages the mitigation program. Within the Recovery Division, the following Sections provide support to the Mitigation Management Section:

- The Floodplain Management Section performs numerous mitigation related activities, training, and technical support functions that are associated with managing statewide local government participation in the National Flood Insurance Program (NFIP), serving as a state cooperating technical partner in developing and updating floodplain flood insurance rate maps and directly performing flood permitting for all state-owned construction projects. The personnel in the Floodplain Management Section include the Floodplain Management Section Manager and State NFIP Coordinator, floodplain management officers, and emergency management officer II. Additionally, the State NFIP Coordinating Office participates with the SHMO in activities to mitigate state priority properties, such as substantially damaged structures, repetitive loss/severe repetitive loss (RL/SRL) properties, floodway structures, violations, compliance and mitigation of state-owned structures, etc., and creates annual reports of these mitigation activities.
- Floodplain Engineering and Mapping Section coordinates with the Mitigation Management section for unmapped areas of the State for Risk MAP (Risk Mapping, Assessment and Planning) products and changes to the floodplain and flood prone areas. Flood Risk Products provide data to enhance hazard mitigation planning activities, development of risk mitigation strategies, and development decisions.
- The Public Assistance staff assist in determining the feasibility of mitigation projects in support of Public Assistance following disasters. The personnel in the Public Assistance Section include the Disaster Section Manager, public assistance coordinators, public assistance specialists, and an administrative assistant.
- Interagency Recovery Coordination assists with Federal and Non-Federal disasters.

The Response Division is responsible for disaster management operations whenever Missouri is affected by an emergency or disaster that may be beyond the capabilities of local governments and includes the Statewide Regional Coordinators, Readiness, and Logistics and Resources sections. Once a state of emergency has been declared by the Governor, the Response Branch opens the State Emergency Operations Center and coordinates disaster response with local governments, state agencies, faith-based and volunteer agencies, private sector partners and FEMA. Mitigation and Floodplain Management Section personnel directly support the Response Division during emergency response and then transition to their normal duties during the recovery. The performance of the initial disaster logistics needs assessments in the disaster areas enables the participating mitigation staff members to perform a quick assessment of potential mitigation success stories, projects, and the possible need for a dedicated hazard mitigation survey team as well as determine if structures might be substantially damaged.

The Preparedness Division develops coordinated statewide response plans and provides training for local and state personnel to effectively respond to emergencies and disasters across the State. The Preparedness Division is also responsible for all-hazards, medical countermeasures, radiological

emergencies and earthquake planning and preparedness activities. One of the Recovery Division's key roles and support effort for the Mitigation Management Section is developing and maintaining the State Hazard Analysis.

The Mitigation Management Section also is supported by the Fiscal Division staff as related to the financial aspects of administering the awarded grants for projects and plans through interaction of the Recipient (state) with FEMA.

SEMA's Recovery Division augments the staff in each of the five sections as needed, with contracted services from Missouri's 19 Regional Planning Commissions (especially planning, planning reviews, and project management.), a local engineering firm (for training, surveying, and low cost—mostly floodplain management—minor engineering projects), and a larger engineering firm with a team of partners (mitigation training, benefit- cost analysis assistance, mitigation application development, map modernization program management, complex engineering projects, special projects, etc.). This enables SEMA to surge during times of disaster to more effectively manage larger numbers of mitigation projects and to keep up with the administrative requirements of managing a larger number of mitigation grants.

7 Enhanced Plan

Contents

7.1. Integration with Other Planning Initiatives

Requirement §201.5(b)(1): [The enhanced plan must demonstrate] that the plan is integrated to the extent practicable with other State and/or regional planning initiatives (comprehensive, growth management, economic development, capital improvement, land development, and/or emergency management plans) and FEMA mitigation programs and initiatives that provide guidance to State and regional agencies.

The State of Missouri has established a comprehensive State hazard mitigation program that is multi-directional. State mitigation initiatives are integrated with Federal Emergency Management Agency (FEMA) programs and are designed to combine both federal and State programs into local planning efforts. State mitigation planning is also integrated with other State emergency management efforts as well as other State and regional planning initiatives.

As initially presented in **Section 4.5.1**, the State Agency Capability Assessment, SEMA provides leadership for the overall state mitigation strategy and works in collaboration with other state agencies to ensure that the various mitigation programs complement each other and work toward achieving the State's overall strategy. While **Section 4.5.1** presented the integration of mitigation into many of the state agency plans, programs, and decision-making tools, this section describes the integration into the State Hazard Mitigation Plan and 2023 planning process. It also discusses integration with USACE mitigation programs, FEMA mitigation programs, new initiatives that have been implemented since the 2018 plan, and integration challenges and successes.

7.1.1 Integration with Emergency Management Planning Initiatives

The State planning documents at SEMA are organized into three volumes: Volume One (1) the Missouri State Hazard Mitigation Plan; Volume Two (2) The Missouri State Emergency Operations Plan (SEOP); and Volume Three (3) The Missouri State Recovery Plan.

Missouri State Emergency Operations Plan (SEOP)

The SEOP outlines the framework for the State of Missouri to save lives, minimize injuries, protect property and the environment, preserve functioning civil government, ensure constituted authority, and maintain economic activities essential to the survival and recovery from natural, technological, and national security hazards. The SEOP, as updated in 2022, is an all-hazards plan which utilizes the concepts and principals of the National Incident Management System (NIMS) and the Incident Command System (ICS) into response operations for the State of Missouri. The plan integrates all phases of emergency management, including mitigation, and all levels of government, including the private sector.

The State Hazard Mitigation Plan is used in coordination with the SEOP to identify the multiplicity of hazards that exist at varying locations and degrees of magnitude throughout the State and to determine the potential impacts of these hazards on residents, property, and the environment. The SEOP references the State Hazard Mitigation Plan as providing the basis for activities proposed during the State planning efforts and recommends its use by state and local officials to plan and prioritize resource allocations. The SEOP encourages local officials to use information in the State Hazard Mitigation Plan to develop their own localized hazard analysis.

The Missouri State Recovery Plan, formerly Annex Q of the SEOP, is under-development as a stand-alone document (Volume Three). The purpose of the State of Missouri Recovery Plan is to provide a conceptual overview of state disaster recovery operations. Volume 3 will identify the key functional roles and responsibilities of the internal and external agencies, organizations, departments, and positions that

participate in disaster recovery operations; this includes management and administration of federal grants for hazard mitigation.

Missouri All-Hazard Emergency Planning Guidance

The Missouri All-Hazard Emergency Planning Guidance was created by SEMA to assist local jurisdictions in developing and maintaining their local all-hazard emergency operations plans (EOPs). The information in the guide complements the SEOP and the National Response Framework (NRF).

The guidance document recommends jurisdictions develop all-hazard functional EOPs that can be implemented during any emergency or disaster (i.e., tornado, earthquake, flood, terrorism event, etc.), rather than developing separate plans for each hazard. The guidance document also recommends the local jurisdiction to utilize existing hazard analyses as a baseline. The hazard identification and risk assessment of the local hazard mitigation plan, with data support for the State Hazard Mitigation Plan, serves this role.

Missouri Emergency Response Commission (MERC)

For the 2023 State Plan Update, SEMA coordinated with MERC and the Missouri Environmental Emergency Response Tracking System (MEERTS) to obtain statewide hazardous materials storage and spill information. This information was utilized in the hazard profile and state risk assessment for hazardous materials release, as well as, the analysis of state-owned and operated facilities. All of the risk assessment results are available to local, state, and federal agencies, as well as the public, through the ArcGIS online application, the Missouri Hazard Mitigation Viewer. While the county-level plans are not required to include manmade hazards in their analysis, this new availability of data and mapping would assist communities with the incorporation of this hazard, as interested.

Additionally, SEMA provided back to MERC the state-owned and operated facilities identified within a 0.5-mile radius of each of the Tier II reporting facilities. This will allow MERC to assist local jurisdictions in addressing response measures, as necessary.

Threat and Hazard Identification and Risk Assessment (THIRA)

The Missouri State Hazard Mitigation Plan is also linked with the Missouri THIRA. The THIRA is updated annually in accordance with the Comprehensive Preparedness Guide 201 and is incorporated into this plan as **Section 3.2** Hazard Identification and **Section 3.3** Hazard Profiles and Risk Assessment.

The THIRA adds context to the hazard information and risk assessment provided by the Hazard Mitigation Plan and identifies desired outcomes and target capabilities based on the core capabilities established by the National Preparedness Goal.

GIS at SEMA

SEMA utilizes ESRI's ArcGIS as a critical tool in emergency management. During an emergency or disaster in Missouri, SEMA's GIS Program harnesses GIS technology to better assess and visualize damage statewide, develop response priorities and logistics planning, and to track progress throughout the response. SEMA GIS also provides important geospatial services that aid in mitigation efforts. GIS-based risk modeling was utilized in the State Plan update for the hazards of flooding, levee failure, dam failure, earthquake, land subsidence/sinkholes, and wildfire. The known locations of areas at risk were mapped utilizing ArcGIS to show areas of the State that are at greatest risk. The plan update also utilized ArcGIS to map the results of statistical and data presentation risk analyses.

Additionally, the 2023 risk assessment data will be available to local, state, and federal agencies, as well as the public, through an ArcGIS online application, the Missouri Hazard Mitigation Viewer. This application

removes a barrier for local mitigation planners to performing all the needed local risk assessments by providing default data developed for the State Plan in both a tabular and spatial mapping format. **Table 7.1** provides a listing of all the maps presented within the 2023 Hazard Mitigation Plan Update and the associated spatial and tabular data available through SEMA and the Missouri Hazard Mitigation Viewer. The Mitigation Viewer can be accessed here: http://bit.ly/MoHazardMitigationPlanViewer2023.

Table 7.1. Spatial and Tabular Data Layers Developed for the 2023 Plan Update

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
General Mapping Layers	n/a	County Boundaries	X	
	n/a	MSDIS Structure Points	X	
		Number of Declared Disasters by County, 1965 - 2022		X
	5.1	Missouri Regional Planning Councils	X	
	5.2	Local Mitigation Plan Status by County, November 2017		X
Assets at Risk		Population by County, 2019		X
		Numerical Change in Population by County, 2010-2019		X
		Percent Change in Population by County, 2010-2019		X
		Numerical Change in Housing Units by County, 2010-2019		X
		Percent Change in Housing Units by County, 2010-2019		X
		Population Density by County, 2019		X
		Percent Change in Population Density by County, 2010-2019		X
		Social Vulnerability Rating, 2010-2014		X
		Percent of Mobile Homes by County		X
		Number of State-Owned Facilities by County		X
		Number of State Leased Facilities by County		X
		Number of DHE Facilities per County		X
		Number of MoDOT Facilities and State-Owned Bridges	X	X
		Number of Tier II Facilities by County		X
Flood Hazard		Flood-Related Disaster Declarations by County, 1965 - February 2018		X
		RiskMAP, DFIRM and Hazus based Depth Grids used in Hazus Analysis by County, 2018		X
		Flood Hazard Areas used in Hazus Analysis, 2018	X	
		Dollars Paid for Flood Insurance Claims by County, 1978-January 2018		X
		Number of Flood Insurance Claims by County, 1978-January 2018		X
		Hazus Countywide Base-Flood Scenarios: Building and Income Loss		X
		Hazus Countywide Base-Flood Scenarios: Building Loss Ratio		X
		Hazus Countywide Base-Flood Scenarios: Displaced People		X
		State Facilities in 100-Year Floodplain	X	
		MoDOT State-Owned Flood Scour Critical Bridges	X	
	4.2	Severe Repetitive Loss Properties by County		X
	4.3	Repetitive Loss Properties by County		X
	4.4	Mitigated Severe Repetitive Loss Properties by County		X
	4.5	Mitigated Repetitive Loss Properties by County		X
	4.6	Participation in CRS	X	
	4.7	Missouri Map Production Status		X
	4.8	Missouri Risk MAP Watersheds	X	
	4.9	Missouri HUC-8 Watersheds - Discovery Status/Planned Discovery	X	
	7.1	DFIRM Status in Missouri as of May 2017		X

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
	7.16	Missouri Communities Participating in the NFIP by County		X
	7.17	Missouri Communities Not Participating in the NFIP by County		X
Levee Failure Hazard		Missouri Counties Impacted by Levees	X	
		Population Exposure: Missouri Levees in USACE Levee Safety Program Providing 100-year or Greater Flood Protection		X
		Residential Building Exposure: Missouri Levees in USACE Levee Safety Program Providing 1 percent annual chance or greater Flood Protection		X
		State Facilities in Areas Protected by Levee	X	
		DHE, MoDOT, and MDC Facilities in Areas Protected by Levee	X	
Dams Failure Hazard		Number of Dams by County		X
		Number of High Hazard Dams by County		X
		Number of Significant Hazard Dams by County		X
		Number of Low Hazard Dams by County		X
		Number of State Regulated Dams by County		X
		Number of Class 1 State Regulated Dams by County		X
		Number of Class 2 State Regulated Dams by County		X
		Number of Class 3 State Regulated Dams by County		X
		Number of State and Federally Regulated Dams with Provided Inundation Areas by County		X
		Number of Structures in State-Regulated Dam Inundation Areas by County		X
		Value of Structures in State-Regulated Dam Inundation Areas by County		X
		Number of Structures in USACE-Regulated Dam Inundation Areas by County		X
		Value of Structures in USACE-Regulated Dam Inundation Areas by County		X
		Population at Risk to Dam Failure in State-Regulated Dam Inundation Areas by County		X
		Population at Risk to Dam Failure in USACE-Regulated Dam Inundation Areas by County		X
		State Facilities in Potential Dam Failure Inundation Zones	X	X
Earthquake Hazard		HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario - Direct Economic Loss to Buildings		X
		HAZUS- MH Earthquake 2% Probability of Exceedance in 50 Years —Ground Shaking and Liquefaction Potential	X	
		HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Total Building Loss		X
		HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Loss Ratio		X
		State Facilities with Potential Earthquake Damages	X	
		State Owned Bridges with Potential Earthquake Damages	X	
Land Subsidence /Sinkhole Hazard		Sinkhole Areas as delineated by the MoDNR	X	
		Number of Sinkholes by County		X
		Number of Mines by County		X
		Vulnerability Rating of Sinkhole Hazard by County		X
		Vulnerability Rating of Mine Subsidence by County		X
		Value of Structures Potentially Impacted by Sinkholes by County		X

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
		Population Potentially Impacted by Sinkholes by County		X
Drought Hazard		Drought Probability by Climate Division Based on Palmer Drought Severity Index 1895 - 2016		X
		Vulnerability Rating of Drought Hazard by County		X
		Annualized Crop Insurance Claims due to Drought, 2007 - 2016		X
Extreme Temp Hazard		Likelihood of Occurrence for Extreme Heat Events by County		X
		Vulnerability Rating of Extreme Heat Hazard by County		X
		Likelihood of Occurrence for Extreme Cold Events by County		X
		Vulnerability Rating of Extreme Cold Hazard by County		X
Severe Thunder-storms Hazard (Includes Wind, Hail, and Lightning)		Likelihood of Occurrence for High Wind Events by County		X
		Likelihood of Occurrence for Hail Events by County		X
		Likelihood of Occurrence for Lightning Events by County		X
		Vulnerability Rating of Severe Thunderstorms Hazard by County		X
		Annualized Property Loss due to High Wind Damage by County		X
		Annualized Property Loss due to Hail Damage by County		X
		Annualized Property Loss due to Lightning Damage by County		X
		Annualized Property Loss Ratio for High Wind by County		X
		Annualized Property Loss Ratio for Hail by County		X
		Annualized Property Loss Ratio for Lightning by County		X
Severe Winter Weather Hazard		Likelihood of Severe Winter Weather Events by County		X
		Vulnerability Rating of Severe Winter Weather Hazard by County		X
		Annualized Property Loss due to Severe Winter Weather Damage by County		X
		Annualized Property Loss Ratio for Severe Winter Weather by County		X
Tornado Hazard		Number of Historic Tornado Events by County		X
		Likelihood of Occurrence for Tornado Events by County		X
		Vulnerability Rating of Tornado Hazard by County		X
		Annualized Property Loss due to Tornado Damage by County		X
		Annualized Property Loss Ratio for Tornadoes by County		X
Wildfire Hazard		Likelihood of Occurrence for Wildfire Events by County		X
		Average Annual Acreage Burned by County		X
		WUI Areas	X	
		Number of Structures within WUI Interface/Intermix Areas by County		X
		Value of Structures within WUI Interface/Intermix Areas by County		X
		Population at Risk within WUI Interface/Intermix Areas by County		X
		Annualized Property Loss due to Wildfire Damages by County		X
Urban/ Structure Fire Hazard		Likelihood of Occurrence for Structural Fire by County		X
		Historical Number of Deaths and Injuries due to Urban/Structure Fire		X
		Vulnerability Rating of Urban/Structure Fire Hazard by County		X
		Annualized Property Loss due to Urban/Structure Fire by County		X
		Annualized Property Loss Ratio due to Urban/Structure Fire by County		X
Hazardous Materials Release		Tier II Reporting Facilities within Missouri, 2021		X

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
Environ-mental Health Emergency		Streams and Lakes Deemed Impaired by 2016 MO Water Quality Report	X	
Public Health Emergency		Vulnerability Rating of Pandemic Influenza Hazard by County		X
Compre-hensive Program	4.2	Severe Repetitive Loss Properties by County, 2022		X
	4.3	Repetitive Loss Properties by County, 2022		X
	4.4	Mitigated Severe Repetitive Loss Properties by County, 2022		X
	4.5	Mitigated Repetitive Loss Properties by County, 2022		X
	4.7	Missouri Counties Currently Undergoing 2-D Modeling Updates		X
	4.8	Missouri Unit Codes (MUC) for Risk MAP Study Approach	X	
	4.9	FY20 and FY21 Funded Counties that will have AMP Produced FIRMs		X

Emergency Management Accreditation Program (EMAP)

Among the extra steps demonstrating Missouri's commitment to mitigation is the participation in the National Emergency Management Accreditation Program (EMAP). EMAP is a voluntary assessment and peer-reviewed accreditation process for state and local government programs responsible for coordinating prevention, mitigation, preparedness, response, and recovery activities for natural and manmade disasters. Accreditation is based on compliance with collaboratively developed national standards, the EMAP Standard. The EMAP Standard is a rigorous yet scalable industry standard for emergency management programs. It was collaboratively developed through a series of working groups of emergency management stakeholders from government, business and other sectors, and continues to evolve to represent the best in emergency management.

By complying with the EMAP mitigation standards, Missouri has demonstrated the importance it places on emergency management, including mitigation, and is better prepared to protect its residents and property from hazards. A reference table is presented in **Section 2.3.3** which outlines the 2019 EMAP standards and the corresponding location in the 2023 State Mitigation Plan.

Other SEMA Plans and Program Initiatives

Additional SEMA mitigation-related plans and programs are presented below. Details are provided in **Section 4.6**.

- Mitigation Management Program
- Missouri Floodplain Management/Floodplain Insurance Programs
- Training and Exercises
- Missouri Disaster Recovery Partnership
- Community Organizations Active in Disaster (COAD)
- Missouri Voluntary Organizations Active in Disaster (MOVOAD)
- Governor's Faith-Based and Community Service Partnership for Disaster Recovery
- Earthquake Program
- Missouri Seismic Safety Commission Strategic Plan for Earthquake Safety in Missouri, Updated in 2007
- Radiological Emergency Preparedness (REP) Program
- All-Hazard Planning Program
- SAVE Coalition

- Statewide Area Coordinator Program
- State Public Assistance Program
- Individuals and Households Program
- State Risk Management Team
- Mitigation Management Website
- Floodplain Management Website
- Risk MAP Global Outreach Plan
- Risk MAP Outreach Website
- Public Information Program
- SEMA Newsletters
- SEMA/MEPA Spring Conference
- Annual Missouri Floodplain and Stormwater Manager's Conference
- Trainings and Workshops
- Regional Planning Commissions
- Ready in 3 Program
- Central United States Earthquake Consortium
- University of Missouri Extension
- Show-Me Response

7.1.2 Integration with Other State and/or Regional Planning Initiatives

The integration of the mitigation plan with other State planning initiatives occurs through regularly scheduled meetings and coordination of the SRMT. This occurs in the mitigation planning process through data-sharing between different State plans, and through participation on planning committees and policy commissions. Through the SRMT, SEMA planners are made aware of the data, programs, and priorities of other State agencies, and other agencies become more knowledgeable about mitigation policies and programs and how they can be integrated into their own plans.

During the plan update, the SRMT reviewed the mitigation-related plans and programs of other State agencies. Since response and recovery plans and programs also typically have a mitigation component, the SRMT incorporated those plans in this review. The purpose of this review was to identify changes, updates, and/or additions since the previous Mitigation Plan update to incorporate relevant data and capabilities into the mitigation plan and to better understand areas where mutual responsibilities and policies could be leveraged.

A summary of integration measures is provided in **Table 7.2**. This includes State agency plans and program initiatives which address economic development, land use development, housing, health and social services, infrastructure, and natural and cultural resources. Additional details of mitigation integrated in these state agencies and programs are provided in **Section 4.5**.

Table 7.2. State Plan Integration with Other State Agency Plans and Program Initiatives

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
Regional Planning Commissions	Economic Development Land Use and Development	One of the best examples of the continued integration of State mitigation planning into regional and local planning initiatives from the last five years is SEMA's relationship with Missouri's RPCs. Because of the RPCs involvement in the development of local mitigation plans, they are more cognizant of mitigation and can consider the basic principles of mitigation in the other planning efforts they coordinate, including highway planning, comprehensive planning, and capital improvement planning. For example, they can promote regional water interconnects between municipalities to create supply alternatives should a hazard event disrupt this critical utility. This would also serve and support homeland security considerations and requirements. The RPCs are active in the implementation of state mitigation actions as support agencies for actions 1, 2, 3, 8, 9, 10, 13, and 14. Through the web-accessible risk assessment data that is part of the 2018 State Plan Update, the Regional Planning Commission mitigation planners will have direct access to risk assessment data collected for the State Plan Update for inclusion and to inform the risk assessments in local plans.	Section 4.2.3 Section 4.5
Department of Health and Senior Services (DHSS)	Health and Social Services	DHSS has internal emergency response plans in place, and as part of the State response the Missouri State Emergency Operations Plan has been fully tested with exercises for all aspects of response and recovery including those relating to public health, emergency response, terrorism, biological, chemical, and radiological/nuclear threats, pandemic influenza, and natural disasters. DHSS incorporates information from the State Mitigation Plan into the development and update of their internal emergency response plans. For the State Mitigation Plan, the hazard profiles and risk assessments for extreme temperature and public health emergencies/environmental issues included updated analysis of statistical data provided by the Missouri Department of Health and Senior Services. Noted integrated programs and documents include: Missouri's Planning Guide for Local Mass Prophylaxis: Distributing and Dispensing the Strategic National Stockpile, dated October 2003; Missouri Pandemic Flu Response Plan, dated December 2011; and Ready in 3 Program.	Section 3.3.7 Section 3.3.19 Section 3.3.21 Section 3.5.19 Section 4.5.1
Seismic Safety Commission	Emergency Management	SEMA participates on the Seismic Safety Commission and provides information for the State's Strategic Plan for Earthquake Safety. This includes incorporation of the enhanced earthquake analysis that was performed for bridges, hazardous materials facilities and essential facilities (schools, fire and medical facilities) to further refine the vulnerability assessment and to identify areas that may warrant further analysis or targeted mitigation.	Section 2.3.1 Section 3.5 Appendix C

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
Central United States Earthquake Consortium (CUSEC) and National Earthquake Hazards Reduction Program	Emergency Management	An enhanced earthquake analysis and report, completed in June and July 2017, was performed as a parallel effort to the 2018 Missouri State Hazard Mitigation Plan Update and brought forward into the 2023 plan update. WSP E&I performed a Hazus V 3.2. Level II Hazus earthquake analysis under a contract with the Central Unites States Earthquake Consortium to incorporate additional hazard data (groundwater depths to refine the liquefaction data inputs); and updated hazardous materials facility and bridge inventory to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. The Central United States Earthquake Consortium provided state-wide National Earthquake Hazards Reduction Program (NEHRP) site classification and soil liquefaction characteristics.	Section 3.3.4 Section 3.5 Appendix C
Department of Agriculture	Land Use and Development	The Department of Agriculture is involved specifically with drought mitigation and mitigating agricultural damage from other hazard events. Critical facilities/ infrastructure data from the Office of Administration for DOA facilities was incorporated into the 2023 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DOA for integration into their agricultural mitigation activities.	Section 3.1.1 Section 3.5 Section 4.5.1
Department of Conservation	Natural and Cultural Resources	MDC is active in the State Emergency Operations Center during all state declared disasters. MDC also participates in all pre-disaster exercises, drills, and planning teams in the State. MDC is a member of numerous levee districts that provide flood protection to crops and structures. All lakes owned by MDC with dams over 35 feet high are designed in accordance with the criteria of the Dam and Reservoir Safety Council of Missouri. The safety or redundancy factor built into these dams and levee construction projects is a higher standard than for commercially constructed projects. MDC participates in a statewide wildfire control program in cooperation with the forest industry, rural fire departments, and other agencies. For the 2023 State Mitigation Plan, the hazard profile and risk assessment for wildfires included updated analysis of statistical data provided by MDC. Critical facilities/ infrastructure data from MDC was incorporated into the exposure and analysis of State assets at risk. This analysis and digital data was provided back to MDC for continued integration into their pre- and post-disaster emergency planning initiatives. Noted integrated programs and documents include: Missouri Department of Conservation (MDC) Statewide Wildfire Control Program; St. Louis Region Healthy Streams and Watersheds; and Wetland Restoration Projects.	Section 3.1.1 Section 3.3.11 Section 3.5 Section 3.5.2 Section 4.2.3 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		The MDC is active in the implementation of state mitigation actions as a support agency for action 15.	
Department of Economic Development	Economic Development Housing	DED administers the Community Development Block Grant program which can provide funding for hazard mitigation and disaster recovery. The DED CDBG Administrative Manual outlines the process for jointly funded SEMA/CDBG Buyout projects. Critical facilities/ infrastructure data from the Office of Administration for DED was incorporated into the 2023 exposure and analysis of State assets at risk. Future development was addressed in the 2023 plan with reference to MDC and their role in economic growth and support of Missouri's businesses by providing data and resources, such as the State Mitigation Plan, for businesses, industries, and communities to grow and expand. Noted integrated programs and documents include: Missouri Consolidated Plan; Community Development Block Grant – Emergency; Grow Missouri Disaster Loan Program; and HUD National Disaster Resilience Competition. The DED and associated CDBG funding are active in the implementation of state mitigation actions as a support agency for action 7.	Section 3.1.1 Section 3.5 Section 4.2.3 Section 4.5.1
Department of Elementary and Secondary Education	Health and Social Services	DESE participates with SEMA for catastrophic event planning in collaboration with the Missouri Center for Safe Schools, and the Missouri United School Insurance Council. For the 2023 State Mitigation Plan, the hazard profile and risk assessment for public health emergencies included updated data provided by DESE. Critical facilities/ infrastructure data from the Office of Administration for DESE was incorporated into the exposure and analysis of State assets at risk. This analysis and digital data was provided back to DESE for continued integration into their catastrophic event planning initiatives. Noted integrated programs and documents include: Catastrophic Event Preparation. The DESE is active in the implementation of state mitigation actions as a support agency for action 8.	Section 3.1.1 Section 3.3.19 Section 3.5 Section 4.2.3 Section 4.5.1
Department of Higher Education	Health and Social Services	DHE convenes meetings of the Higher Education Subcommittee of the Homeland Security Advisory Council approximately five times per year as a pre-disaster initiative. The Subcommittee promotes pre- and post-disaster emergency planning initiatives on all higher education campuses in Missouri, shares best practices, and ensures that collegiate institutions throughout the State are informed about and engaged in emergency planning.	Section 3.1.1 Section 3.5 Section 3.5.3 Section 4.2.3 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		Critical facilities/ infrastructure data from DHE was incorporated into the 2023 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DHE for continued integration into their pre- and post-disaster emergency planning initiatives. Noted integrated programs and documents include: Department of Higher Education (DHE) Disaster Resistant University KC Metro Community Colleges. The DHE is active in the implementation of state mitigation actions as a support agency for action 8 and 15	
Department of Insurance, Financial Institutions, and Professional Registration	Economic Development	The Department of Insurance, Financial Institutions, and Professional Registration has resources for insurance customers, companies, and producers. The department is able to promote flood and earthquake insurance as a pre-mitigation measure. Additionally, the department enforces *RSMo 379.975,* which requires insurers to provide information to applicants and policyholders about earthquake insurance for properties located in the New Madrid Seismic Zone and *RSMo 379.978,* which requires all insurance companies that provide earthquake coverage to prepare a written disaster plan that addresses earthquakes. Critical facilities/ infrastructure data from the Office of Administration for DIFP was incorporated into the 2023 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DIFP for integration into their mitigation initiatives, including insurance purposes. Noted integrated programs and documents include: RSMo 379.975 and Section 207 of the Flood Insurance Reform Act of 2004.	Section 3.5 Section 4.5.1
Department of Labor and Industrial Relations	Economic Development	When a Missouri county or region is impacted by a natural disaster or hazardous condition such as flooding or inclement weather, the Labor Department has the authority to suspend in-person reporting required of the unemployed for a period of time. This helps to assist in the post-disaster recovery of the local communities. Critical facilities/ infrastructure data from the Office of Administration for DLIR was incorporated into the 2018 exposure and analysis of State assets at risk.	Section 3.1.1 Section 3.5 Section 4.5.1
Department of Mental Health	Health and Social Services	DMH maintains an All-Hazard Emergency Operations Plan as a pre-disaster measure. The plan, developed with the input of the Mental Health Statewide Disaster Response Planning Committee, is designed to enhance department planning and response activities and minimizes the effects of disasters (natural, manmade or other) on DMH consumers and the residents of Missouri. The Department also ensures the DMH facilities maintain and exercise facility emergency operations plans; provide education	Section 3.1.1 Section 3.5 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		and training for people with special needs, schools, healthcare workers, and other first responders to mitigate the emotional impacts of disaster events; and maintains a Continuity of Operations Plan and a Pandemic Flu annex to help mitigate against the effects of displacement. Critical facilities/ infrastructure data from the Office of Administration for DMH facilities was incorporated into the 2023 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DMH for integration into their mitigation initiatives, including incorporation into their Hazard Emergency Operations Plan. Noted integrated programs and documents include: All-Hazards Emergency Operations Plan and Mental Health Disaster Communication Guidebooks.	
Missouri Department of Natural Resources	Natural and Cultural Resources	The department administers various projects designed to reduce stream bank erosion, reduce localized flooding, improve drainage, reduce discharge, improve water quality, ensure safe drinking water, and make sure that dams are constructed, maintained, and operated in a safe manner. For the 2023 State Mitigation Plan, the hazard profile and risk assessment for dam failure, earthquakes, land subsidence/sinkholes, drought, wildfires, hazardous materials release, and public health/environmental issues incorporated data provided by MoDNR. Additionally, for the land subsidence/sinkhole hazard, MoDNR has created a statewide sinkhole inventory that was used in coordination with new sinkhole data developed for newly mapped floodplain areas. The new sinkhole data is being developed using methods outlined in the Missouri Sinkhole Analysis Policy paper "Analysis and Communication of Flood Risk for Sinkholes in Missouri" funded in 2016 by SEMA. Critical facilities/ infrastructure data from the Office of Administration for MoDNR facilities was incorporated into the 2023 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DMH for integration into their mitigation initiatives. Noted integrated programs and documents include: Dam and Reservoir Safety Program; Dam and Reservoir Safety Program Emergency Action Plan Template; Geological Survey Program's Earthquake Response Plan and Hazards Mapping; Central United States Earthquake Consortium (CUSEC); Missouri Water Supply Study, Amended 2009; Stormwater Improvements Program; DNR Missouri Drought Plan; and the DNR State Water Plan. MoDNR is active in the implementation of state mitigation actions as a support agency for action 9, 10, 11, and 17.	Section 3.3.3 Section 3.3.4 Section 3.3.5 Section 3.3.6 Section 3.3.11 Section 3.3.16 Section 3.3.19 Section 4.2.3 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
Missouri Dam and Safety Reservoir Program	Natural and Cultural Resources	The Missouri Dam and Safety Reservoir Law of 1979 establishes a dam safety program within MoDNR to ensure that dams in the state are constructed, maintained, and operated in a safe manner. The Dam and Reservoir Safety Program is leading the effort to develop Emergency Action Plans (EAPs) for regulated dams that will help save lives and reduce property damage during a dam safety emergency. Additional dam safety initiatives are coordinated with the USACE. MoDNR State-regulated dam inventory as reported to the Missouri Spatial Data Inventory System, supplemented with additional state hazard class information from the Dam Safety Program for 2018 State Plan update.	Section 3.3.3 Section 4.5.1
Department of Public Safety	Emergency Management	The Missouri Office of Homeland Security (OHS) is a part of the DPS, and directly under the Director of the DPS. The Department's desired outcomes that are specific to mitigation efforts are: to mitigate the threat of terrorism; reduce preventable injuries and fatalities; interoperable communications for law enforcement and emergency services; increase crime prevention; and to improve the ability to respond and provide recovery from all "hazard events". Critical facilities/ infrastructure data from the Office of Administration for DPS facilities was incorporated into the 2023 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DPS for integration into their mitigation initiatives.	Section 3.1.1 Section 3.3.21 Section 3.5 Section 4.5.1
Division of Fire Safety	Emergency Management	MDFS is tasked with the development of the Statewide Mutual Aid program to assist other responder disciplines in establishment of their own mutual aid systems. MDFS also continues to actively promote the enactment of a statewide fire code. For the 2023 State Mitigation Plan, the hazard profile and risk assessment for urban/structure fires was created separately from the wildfire hazard. Noted integrated programs and documents include: Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE), dated 2008	Section 3.3.15 Section 4.5.1
Office of Homeland Security	Emergency Management	The homeland security coordinator, who works directly for the director of the DPS, manages the Office of Homeland Security and is tasked with implementing Missouri's Homeland Security Strategy. The coordinator is responsible for the overall Homeland Security program in Missouri, and works with the Homeland Security Advisory Council, the Regional Homeland Security Oversight Committees, and the various initiatives to ensure that Missouri's program is focused on an all threats, all hazards approach.	Section 3.3.21 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
State Highway Patrol	Emergency Management	The State Highway Patrol provides all officers with training on weapons of mass destruction and gives additional terrorism training to sergeants and staff officers. For the 2023 State Mitigation Plan, the hazard profile and risk assessment for land subsidence/sinkholes, civil disorder, and mass transportation included updated data provided by the Missouri State Highway Patrol Statistical Analysis Center. Noted integrated programs and documents include: Missouri Homeland Security Alert Network.	Section 3.3.5 Section 3.3.13 Section 3.3.17 Section 4.5.1
Department of Social Services	Health and Social Services	The Department of Social Services (DSS) is the lead state agency responsible for coordinating mass care activities during disaster events. Critical facilities/ infrastructure data from the Office of Administration for DSS facilities was incorporated into the 2023 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DSS for integration into their mitigation initiatives and disaster event planning activities. Noted integrated programs and documents include: Emergency Operations Plan, Children's Division, dated 2008.	Section 3.1.1 Section 3.5 Section 4.5.1
Department of Transportation	Infrastructure	MoDOT uses mitigation in its capital improvement planning and environmental planning which involves locating facilities, retrofitting bridges, and assessing open space and floodplain issues. MoDOT personnel provide technical assistance to various emergency management programs, including mitigation. In addition, MoDOT incorporates flood and earthquake standards into new bridge designs and is working on a database that identifies which Missouri bridges have been constructed or retrofitted to earthquake design standards. MoDOT also works on major river bridge projects and wetland reestablishment and rehabilitation. The agency also enforces hazardous materials regulations and manages the registration and licensing of carriers who haul hazardous waste through the State. For the 2023 State Mitigation Plan, the hazard profile and risk assessment for severe winter weather, hazardous materials release, and mass transportation included updated data provided by MoDOT. Critical facilities/ infrastructure data, including scour critical bridges, from MoDOT was incorporated into the exposure and analysis of State assets at risk. This analysis and digital data was provided back to MoDOT for integration into their mitigation initiatives and disaster event planning activities. Noted integrated programs and documents include: Statewide Transportation Improvement Program.	Section 3.1.1 Section 3.3.9 Section 3.3.16 Section 3.3.17 Section 3.5 Section 4.2.3 Section 4.5.1 Appendix C

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		An enhanced earthquake analysis and report, completed in June and July 2017, was performed as a parallel effort to the 2018 Missouri State Hazard Mitigation Plan Update. This enhancement included an updated bridge inventory to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. Vulnerable bridge data was provided back to MoDOT for consideration. MoDOT is active in the implementation of state mitigation actions as a support agency for action 15.	
Office of Administration	Economic Development	The Office of Administration enforces floodplain management regulations for state facilities. For Missouri state-owned or operated facilities, SEMA applied FEMA's guidelines for determining critical facilities to the asset use/facility types. Over 8,000 OA facilities were determined to be critical facilities. The inventory was then geo-referenced with available information (latitude longitude or address) and utilized in the exposure and analysis of State assets at risk. Additionally, for the 2023 State Mitigation Plan, the hazard profile and risk assessment for cyber disruption included updated data provided by OA. The OA is active in the implementation of state mitigation actions as a support agency for action 15.	Section 3.1.1 Section 3.3.14 Section 3.5 Section 4.2.3 Section 4.5.1
Public Service Commission	Economic Development	The Missouri Public Service Commission (PSC) regulates investor-owned public utilities operating in Missouri that can be affected by disaster events. For the 2023 State Mitigation Plan, the hazard profile and risk assessment for utilities (disruption and system failures) included updated data provided by PSC. Noted integrated programs and documents include: Missouri Energy Task Force Action Plan, 2006. The PSC is active in the implementation of state mitigation actions as a support agency for action 12.	Section 3.3.22 Section 4.2.3 Section 4.5.1

As noted throughout **Table 7.2**, critical facilities/ infrastructure data from numerous State agencies were incorporated into the exposure and analysis of State assets at risk. For those facilities for which GIS data was provided, the State agencies have been provided with the results indicating specific facilities potentially at risk to inundation from failure of state-regulated and USACE-regulated dams, flooding from a 100-year flood event, and levee failure; location relative to sinkholes and potential wildfires; and damage from an earthquake event with a 2% probability of exceedance in 50 years. Results were provided in both GIS (geodatabase) and Excel spreadsheet formats. Provision of this data is provided specifically so that those State- agencies are made aware of potential risks to determine if mitigation opportunities are necessary and/or feasible.

7.1.3 Integration with USACE Mitigation Programs and Initiatives

The USACE Kansas City District is charged with leading coordination for the USACE in Missouri. In support of the Missouri State Hazard Mitigation Plan update, the USACE has contributed to mitigation planning efforts through integration of:

- Civil Works Programs
- Risk assessments
- Actions supporting hazard mitigation
- Risk communication

The Lead Silver Jackets Coordinator for Missouri participates on the SRMT, representing all the USACE districts within the state. Each district also has a Silver Jacket Coordinator, who is encouraged to attend. The Lead Silver Jackets Coordinator provides regular status updates at the SRMT meetings, including detailed information on active USACE Civil Works projects and programs; supports risk assessment development, providing input and data, as requested; and assists in update and development of mitigation actions, as related to USACE risk reduction measures.

Civil Works Programs

Several relevant USACE Civil Works programs are integrated with the State Hazard Mitigation Plan and planning process and are further defined below:

- The **USACE Levee Safety Program** activities have included establishing a National Levee Database, inspecting levees, communicating risks, taking steps to reduce risks, and establishing a levee safety portfolio internally at USACE for prioritizing levee work. Integration efforts include the addition of a new mitigation action (See Section 4) to encourage the creation of a State-level Levee Safety Program similar to MoDNR's Dam and Reservoir Safety program.
- The **USACE Dam Safety Program** focuses on the large reservoirs, many of which are multipurpose. Reservoirs act together with levees and other infrastructure to reduce impacts of floods, and the reservoirs may also maintain flows for navigation downstream. The program is a little older than the USACE program on levee safety and also has a risk portfolio for prioritizing dam work. Integration efforts include data delivery for the dam failure hazard profile and risk assessment.
- The **USACE Flood Risk Management Program** includes planning studies (General Investigations, or GI, and other programs), projects under design phase (Preconstruction Engineering and Design, or PED), and others in construction phase (Construction General, or GI) within the State of Missouri. Integration efforts include data delivery for the flood hazard profile and risk assessment, as well as, implementation of structural flood mitigation projects at the local level.

It is an objective of the program to reduce the Nation's flood risk and increase resilience to disasters.

- **USACE Civil Works Emergency Management Program** addresses activities such as flood fighting and the rehabilitation of damaged infrastructure, such as levees or dams. In addition, major disasters and emergencies are also coordinated through this program. Integration efforts include data delivery for the state capability assessment. It is an objective of the program to support DHS/FEMA to provide life-cycle public works and engineering support in response to disasters.

Risk Assessments

The USACE Dam Safety Program developed and released dam safety action classifications (DSACs) between 2006 and 2009. The system is intended to provide consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are placed into a DSAC class based on their individual dam safety risk considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences.

For the 2018 State Mitigation Plan Update and dam failure risk assessment, the Silver Jackets coordinator obtained inundation areas for USACE dams that could impact Missouri, including USACE dams outside and upstream of Missouri that have inundation pathways that impact areas and communities within the State. These were brought forward into the 2023 Plan.

In May of 2012, the Levee Safety Program began a similar effort with the state hazard mitigation teams. Silver Jackets Coordinators and Levee Safety Program Managers are establishing the revised Levee Safety path forward with state teams and plan specific actions through new processes.

- Both the dam safety action classifications and levee safety action classifications, as available, were utilized in the State Hazard Mitigation Plan to determine vulnerability (See **Sections 3.3.2** and **3.3.3**).

Actions Supporting Hazard Mitigation

Similar to mitigation actions, the USACE develops interim risk reduction measures related to the USACE Dam and Levee Safety Programs. Interim risk reduction measures (IRRMs) are effective, interim actions taken to reduce flood risks while longer term solutions are planned and implemented. IRRMs are in line with the State Hazard Mitigation Plan's Goal #1 (see **Section 4.1**) to implement mitigation actions that improve the protection of human life, health, and safety from the adverse effects of disasters. IRRMs are a critical part of responsible, adaptive flood risk management.

Examples of IRRMs for dams in Missouri include the following:

- **Smithville Lake**. The Smithville lake dam has had observed seepage at the left abutment since initial pool filling, which has generated stability concerns. A large amount of instrumentation was installed to better define the seepage pressures beneath the dam during the 1980's, which has provided data that substantiate adequate stability. Drainage provisions were also installed to reduce seepage pressures.

- **Rathbun Lake.** Two drainage systems were installed, one at the Chariton embankment in 1988 and deepened in 1994, and one at the Buck Branch embankment in 2011. Spillway erosion was determined to be adequate to pass the spillway design flood, but is a maintenance concern because of the increased likelihood of use. During the 2010 flood, the stilling basin was improved to handle higher flood control releases. Downstream channel capacity has likely increased in recent years due to changes in land use. A Water Control Manual revision study

has been initiated, which should lead to higher allowable releases and a better balance between lake benefits and downstream benefits.

- **Pomme de Terre Lake.** The original stilling basin had severe concrete erosion problems because of rockfill and resulting ball milling during discharges. The stilling basin concrete was repaired in 2009-11. The dam was initially placed in the DSAC 3 category because of the stilling basin condition and concern for foundation and abutment seepage concerns through rock joints, filters in the embankment, and possible deterioration in the grout curtain. Secondary concerns included stability issues in the rim dike and possible spillway erosion with spillway design floods. A periodic assessment was completed in 2012 that addressed all these concerns and downgraded the project risk to the DSAC 4 level.
- **Stockton Lake.** IRRM measures addressing the stability concerns included replacing caulking on the spillway piers, adding/replacing instrumentation to measure water levels below the spillway structure and to monitor seepage on the right abutment.
- **Mark Twain Lake.** IRRM measures include scour survey, settlement survey, vegetation maintenance, flood damage repair, stilling basin inspection, periodic inspection, additional dam safety inspections, additional walk over inspections, post-earthquake inspections, annual periodic inspection review, periodic assessment, toe drain inspection, update PMP/PMF, update pool frequency data, seepage analysis, emergency action plan, EAP exercise, dam safety training, annual meetings with local authorities, communication plan, news and press releases, stockpile materials, equipment availability, new inundation maps
- **Lake Wappapello.** IRRM measures include additional piezometer installation, update earthquake instrumentation, periodic inspection, stilling basin inspection, foundation drain inspection, dam safety training, SPRA recommendations, spillway erosion study, inundation maps, P&S to repair and paint gates, additional piezometer readings, additional walk-over inspections, additional dam safety inspections, annual periodic inspection review, EAP exercise, repair and paint gates, remove vegetation, annual meetings with local authorities, EAP, news and press releases, communications plan.

Planning and implementing IRRMs for levees are ultimately the levee sponsors responsibility. The USACE districts that operate and/or maintain levee systems are required to develop IRRM plans. For federally authorized - locally operated and maintained levee systems, IRRMs are ultimately the levee sponsors' decision but the USACE may advise and recommend the need for IRRM's. Potential USACE programs for joint collaboration of IRRM's (USACE participation in advising levee sponsors concerning IRRMs) include Silver Jackets interagency teams, Planning Assistance to the States (PAS), or Floodplain Management Services (FPMS). Some events that may lead to recommendations for IRRM's include:

- Scheduled inspections
- Risk assessments or levee screenings
- Flood events or incidents revealing performance issues
- System-wide Improvement Framework requests for participation in the PL 84-99 recovery assistance program

Risk Communication

As previously noted, the Lead Silver Jackets Coordinator provides USACE status updates to the SRMT. In the updates, current projects (General Investigations, or studies, and Construction General) including dam and levee construction and studies, are provided. The USACE programs, Floodplain Management Services (FPMS) program, Planning Assistance to States (PAS), and any Silver Jacket Pilot Projects are

also listed in the status updates. The updates can also be found on each of the USACE districts' websites.

Additional forms of risk communication with the USACE include:

- The **Regional State Risk Management Team** is a combination of the hazard mitigation teams in the four-state region of Kansas, Iowa, Missouri, and Nebraska, with a focus on the Missouri River. The team is primarily composed of the state agency officials directing those state teams and representatives from the local USACE Districts. The SRMT co-leads are one of the four states leading this broader team.
- Tools such as **fact sheets and Strong Points**, a USACE news bulletin, on topics including risk assessment, risk-informed decision-making, and IRRMs specifically developed for communicating flood risk associated with levee systems are available through a USACE Silver Jackets Coordinator.
- The USACE offers assistance in questions about floodplains through the **Floodplain Management Services Program**.

Interagency Non-Structural Project

Through the Silver Jackets program, SEMA has proposed, and was awarded funding in late 2017, to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy will identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy will rank the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state.

Experts from a variety of State and Federal agencies and local partners will work together to develop the strategy. The work will include a series of five partner meetings to identify the potential relevant factors, determine which factors to incorporate into the overall buyout strategy, and develop the strategy to append to the State Hazard Mitigation Plan once it is complete.

The strategy will also allow the state to act more expeditiously following a disaster. This project will contribute products that will serve other active interagency nonstructural projects within USACE St. Louis District's Silver Jackets Program. Specifically, actions involving buyouts for the floodplain management plans addressing recent Meramec Basin flooding.

Other USACE Programs Conducting Hazard Mitigation

Leading the nation's environmental engineering efforts, the USACE manages one of the largest federal environmental missions: restoring degraded ecosystems; constructing sustainable facilities; regulating waterways; managing natural resources; and, cleaning up contaminated sites from past military activities. USACE environmental cleanup programs focus on reducing risk and protecting human health and the environment in a timely and cost-effective manner. USACE manages, designs and executes a full range of cleanup and protection activities, such as:

- Cleaning up sites contaminated with hazardous, toxic or radioactive waste or ordnance through the Formerly Used Defense Sites program
- Cleaning up low-level radioactive waste from the nation's early atomic weapons program through the Formerly Utilized Sites Remedial Action Program
- Supporting the U.S. Environmental Protection Agency by cleaning up Superfund sites and working with its Brownfields and Urban Waters programs

- Supporting the Army with the Base Realignment and Closure Act program
- Ensuring that facilities comply with federal, state and local environmental laws
- Conserving cultural and natural resources
- Integration efforts for the USACE environmental missions include data delivery for the for environmental consequences in the hazard profiles, as well as, implementation of mitigation projects at the local level.

7.1.4 Integration with FEMA Mitigation Programs and Initiatives

The State Mitigation Plan is integrated with FEMA mitigation programs primarily through its mitigation strategy, the local mitigation planning program, and the floodplain management functions.

Hazard Mitigation Assistance Grants

Mitigation actions, as described in detail in **Section 4.2** and expanded in **Section 7.5**, are designed to reduce long-term risk in Missouri and improve the State's eligibility for and management of FEMA Hazard Mitigation Assistance (HMA) grant programs listed below:

- Hazard Mitigation Grant Program (HMGP - 404)
- Pre-Disaster Mitigation Program (PDM)
- Building Resilient Infrastructure and Communities (BRIC) Program
- Flood Mitigation Assistance (FMA) Program
- FEMA Public Assistance Mitigation (PA - 406)

The table below presents the number of total mitigation projects (HMGP, PDM, BRIC and FMA) approved or completed since 2002 to demonstrate integration. The rows highlighted in grey note project types unique to the 2018-2021 timeframe, demonstrating the variation in mitigation measures providing resilience to Missouri communities.

Table 7.3. Summary of FEMA Funded Mitigation Projects, 2002-2022

Project Type	Action Category	Number of Projects	Estimated Funding Amount
State and Local Hazard Mitigation Plans	M1	269	$11,674,149
Flood Buyouts	M4	115	$65,634,037
Warning Systems	M3	21	$682,193
Flood Elevations	M5	3	$488,573
Tornado Safe Rooms	M6	239	$286,333,188
Tornado Safe Rooms - Multipurpose	M6	1	$686,493
Basin	M9	1	$1,333,333
Bridge Replacements	M9	1	$449,787
Culvert	M9	2	$553,625
Low Water Crossings	M9	10	$1,321,142
Streambank Stabilizations	M9	2	$92,267
Water Supply Interconnects	M9	1	$66,701
Buried Electric Lines	M12	10	$11,959,530
Infrastructure Protective Measures	M9	4	$1,760,546

Project Type	Action Category	Number of Projects	Estimated Funding Amount
Utility Protective Measures	M9	2	$968,946
Generators	M9	6	$517,678
State 5% Initiative Projects	M13	22	$2,352,244

Through implementation of the FEMA HMA grants, SEMA further integrates and utilizes the information provided by FEMA including:

- FEMA P-320, Taking Shelter from the Storm: Building a Safe Room for Your Home or Small Business (5th Edition, 2021)
- FEMA P-361, Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms (4th Edition, 2021)
- FEMA Safe Room Operations and Maintenance Plan Checklist (June 2022)
- Mitigation Planning Guidance
- FEMA National Flood Hazard Layer GIS Web Services
- FEMA BCA Toolkit and Supplemental Reference Guide
- Include FEMA timeline for sub-application submissions

Building Resilient Infrastructure and Communities (BRIC) Program

The Fiscal Year 2020 BRIC and FMA application cycle opened on Sept. 30, 2020, and closed on Jan. 29, 2021. FEMA received 1,216 subapplications requesting an estimated $3.99 billion in federal funding. The state of Missouri submitted 10 BRIC applications requesting $12.7 million in funding. The applications included saferoom/shelter (7), utility and infrastructure protection (1), management costs (1), and generator (1). The Missouri applications addressed nine small, impoverished communities which follows FEMA's commitment to deliver the grant program funding with equity.

Flood Mitigation Assistance (FMA)

The Fiscal Year 2020 FEMA application cycle mirrored the BRIC cycle and opened on Sept. 30, 2020, and closed on Jan. 29, 2021. For the FMA program, FEMA received 236 subapplications, which is the most subapplications received to date for this grant program, requesting $398.5 million in federal funds. The state of Missouri submitted 2 applications requesting $128,553 in funding. The applications included flood control (1) and management costs (1).

Public Assistance C-G

Since 1998, there have been almost 9,000 permanent Public Assistance projects completed within the State. This includes:

- C - Roads and Bridges – 7,259
- D - Water Control Facilities - 73
- E - Public Buildings - 712
- F - Public Utilities - 599
- G - Recreational or Other - 341

The integration of hazard mitigation measures into the permanent restoration of these damaged facilities during post-disaster recovery through the Public Assistance Mitigation (406) program is presented in **Section 7.6** of this Section.

Risk Mapping, Assessment, and Planning (Risk MAP)

Risk MAP is an action-driven program through community participation, adopting mitigation planning, communicating risk to citizens, implementing mitigation actions to reduce risk, and utilizing mitigation plans to secure grant funding. Through Risk MAP, FEMA provides information to enhance local mitigation plans, improve community risk awareness outreach, and increase local resilience to flooding. Through collaboration with State, Tribal, and local entities, Risk MAP delivers quality data that increases public awareness and leads to action that reduces risk to life and property.

Missouri Risk MAP Program Business Plan

SEMA has developed a 5-year Combined Strategic and Community Engagement and Risk Communication (CERC) and Risk MAP Business Plan to emphasize its comprehensive and integrated approach that includes floodplain mapping, risk assessment and mitigation planning unified by risk communication that meets or exceeds FEMA goals and program intent. The Business Plan outlines the path for the state of Missouri to reach “Map Maintenance” status by Fiscal Year (FY) 2022. Activities following the Map Maintenance Status will focus on mapping individual streams, rapid growth communities, areas that experienced a flood of record or other significant topographic accuracy changes, hydrologic and/or hydraulic changes, or other natural/man-made features that would alter the accuracy of the flood risk assessments.

Mapping

In 2018, in support of FEMA Moonshots, SEMA was among the first CTP in the nation to fully commit to FEMA’s goal of 2D modeling for all streams in the NFIP as a standard practice. 2D modeling is performed using the U.S. Army Corps of Engineers (USACE) HEC-RAS 6.X software, which is an industry standard, and is available free of charge. This sweeping update in modeling technology provides a boost to the nation’s ability to define flooding risk more accurately. The USACE released the first 2D software version in 2018 in order to enable initial usage of the software, with the knowledge that additional functionality was still in development and would be released moving forward. Forward thinking at SEMA allowed the agency to maneuver, though this Business Plan process, to switch to the 2D modeling process and provide the most accurate flood risk identification for its over 6 million citizens.

Additional software components have now been developed by the USACE and a beta version of HEC-RAS 6.0 was released in December 2020, becoming a full release in May 2021. It is anticipated by the modeling industry that 2D HEC-RAS will be the standard for modeling for the next decade and beyond. With forethought, in 2020, SEMA decided to move its normal funding request for map panel production and post preliminary processing forward by one year and use the normal request for those funds toward updating models that were not currently effective, to HEC-RAS 6.0-based models to extend the useful life of the models. Key updates to the HEC-RAS 6.0 software included; the ability to model bridges as unsteady bridges versus simulating with culverts; and the ability to have spatially varying excess rainfall across the 2D model area, mesh cell by mesh cell; and infiltration now occurs in HEC-RAS as opposed to occurring outside the model and then inputting the single values for the modeled areas.

As of May 2023, SEMA has updated 2D modeling for 100 of the 114 counties in the state to a countywide digital flood insurance map, representing 61,526 square miles. Funding has been requested through the 5 Year Business Plan to update the remaining counties for a full 2D coverage statewide.

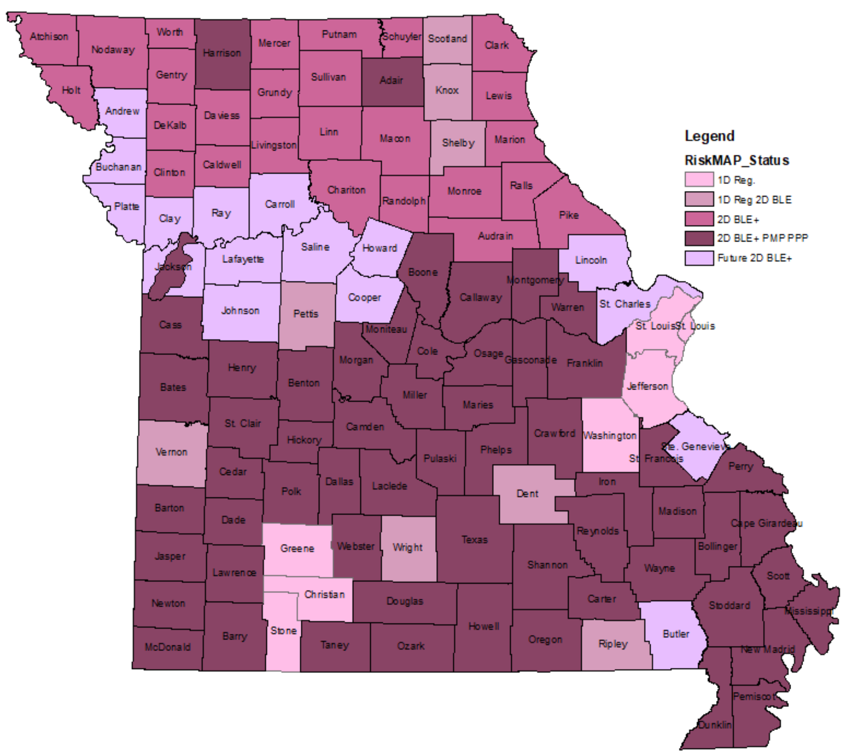
In 2018, SEMA identified gaps to the thirty-eight rural underserved communities who did not qualify for floodplain updates based on population metrics in the original MapMOD program of funding. These identified communities still had paper maps only and most of those only covering the county seat. The Paper Inventory Reduction (PIR) funding mechanism provided an avenue to address this gap and SEMA was among the first in the nation to take advantage of this funding opportunity. As of 2023, all PIR counties have been mapped with digital floodplains, Flood Risk Dataset (FRD) and all either have already been or are funded for 2D model development. The areas identified as disadvantaged in the Justice 40 initiative are directly correlated to the PIR counties.

SEMA further addresses this gap through the active use of the Outreach Site where local stakeholders can review and comment on draft data with only the need for an internet connection and not the need for costly GIS software. SEMA continues to fill this gap by providing final datasets on the Public Awareness Portal for use after the data goes effective to continue providing an avenue for local officials access to these extraordinary datasets with only an internet connection needed.

Assessment

This 2023 State Mitigation Plan update is integrated with the Risk MAP activities within the State through the utilization of the FIRM depth grids for 79 Missouri Counties and the City of St. Louis and through the utilization of Hazus-generated floodplain data for the remaining 35 counties. By integrating the existing depth grids generated as part of the Risk MAP products and developing depth grids based on the DFIRM databases, the flood risk assessment for these areas is much more refined and accurate. The State intends to continue to incorporate FIRM depth grids for additional counties as they become available.

Figure 7.1. Risk MAP Status in Missouri, May 2023



Planning

Local Mitigation Plans

As part of a FEMA CERC funded grant, a User Guide and accompanying Workshop was developed which utilizes the available SFHA and the MSDIS Structure points, described in **Section 4.2** to identify mitigation actions and potential areas of mitigation interest that can be used in local mitigation planning efforts. These actions are categorized according to the six broad mitigation categories defined by FEMA. Specific examples from each of the 23 subcategories under flooding are then shown. Nine workshops were held across the state in 2017 where this User Guide and Workshop material were presented. In 2023 and 2024, it is planned that these workshop materials will also be distributed at the Community Coordination Officer (CCO) meetings being held across the state as part of the mapping updates.

SEMA created a local mitigation plan outline and accompanying workshop to aid local and regional planning efforts in meeting the FEMA Guidance and Specifications for Local Plans with minimal cost and time expenditures. To date 12 workshops have been held across the State to present this Outline, this includes workshops held annually in 2019, 2020, and 2021. More are planned for 2023. Additionally, meeting kits for each of the three meetings required for local plans were developed that contain templates for agendas, invitation letters, sign-in sheets, presentations, sample public surveys, data collection questionnaires, action tracking spreadsheets, STAPLEE worksheets and meeting minutes.

Other actions include helping local governments with their multi-jurisdictional local hazard mitigation plans (new and updated), which are funded primarily through FEMA's Building Resilient Infrastructure and Communities program and Hazard Mitigation Grant Program, and to provide training and outreach to local governments on the benefits of FEMA mitigation programs and how they can get involved.

Risk Communication

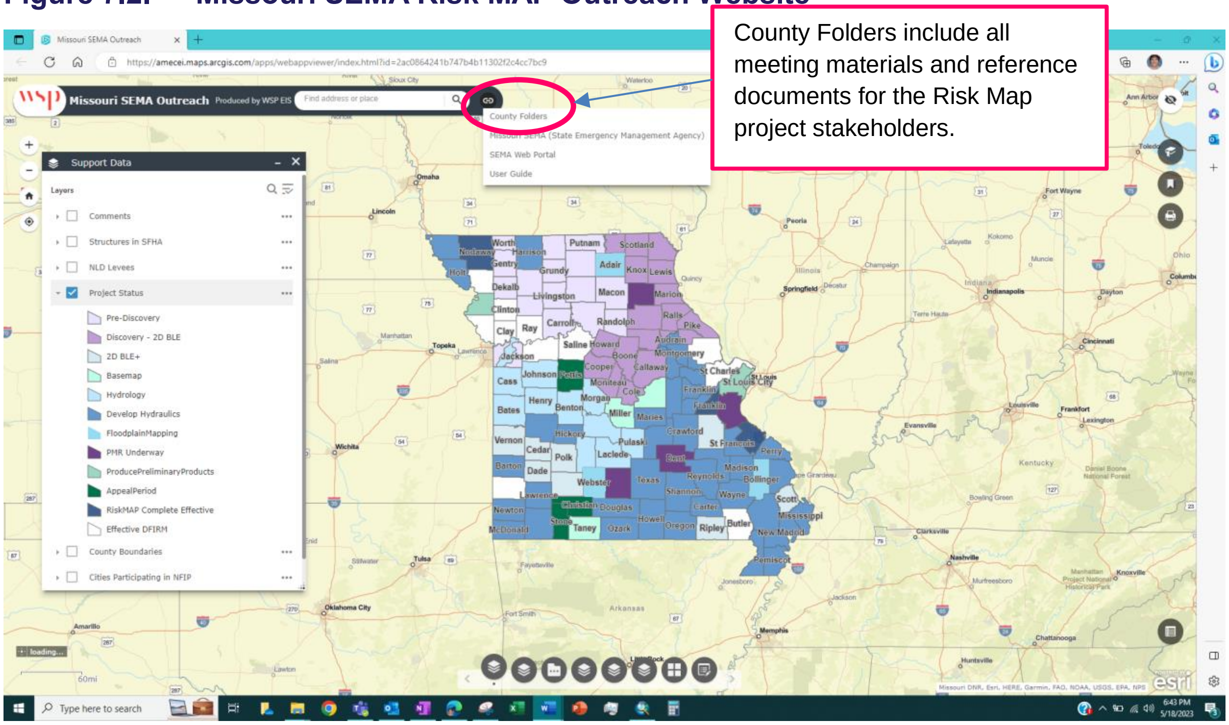
SEMA is fully committed to ongoing communications with the Risk MAP project area stakeholders for each mapping study, as well as, incorporating mitigation into the process. Communication and outreach includes:

- Meetings conducted within the project study areas for Project Initiation/Discovery, Flood Study Review, Community Compliance Officer (CCO) meetings and Open Houses. Areas of mitigation interest (AOMI) and mitigation actions identified during these meetings are added to FEMA's mitigation action tracker, included in local hazard mitigation plan, and included in the prioritization process for SEMA mitigation project approvals.
- Outreach website (http://bit.ly/MOSEMAOutreach) showing flood mapping project status and meeting materials, including mitigation topics and reference materials (see **Figure 7.2**).
- Answering any communications received from persons in a study area and quarterly communications sent to the project stakeholders.
- Coordination with the State NFIP Coordinator and SEMA staff to assist communities to join the NFIP if they have not previously done so and to update ordinances during the Community Map Adoption Period.
- Training workshops for communities who have recently had mapping update or are being updated so that community officials can better understand the powerful tools available to them for mitigation action identification and hazard mitigation planning.

Consistency of personnel attending outreach meetings is also a large component of SEMA's outreach program. The same staff attend all the meetings to ensure that follow through on needs are met and

relationships with the State are built and maintained from year to year.

Figure 7.2. Missouri SEMA Risk MAP Outreach Website



SEMA has developed an Online Loss Avoidance Tool, as further described in **Section 7.4**, which will be accessible at the SEMA Website. This Loss Avoidance Tool allows for "what If" scenarios to be conducted with minimal time invested by allowing users to draw a selection area or upload an already defined selection area such as a Disaster Declaration Area and export the Losses Avoided for the Buyout locations that fall within the selection area. This data can easily become a part of any report or local plan.

National Flood Insurance Program and the Community Rating System

Coordination of the National Flood Insurance Program was transferred from the Department of Natural Resources to SEMA in 1995. Since that time, there has been an enormous effort by SEMA staff to bring heightened awareness and technical assistance to local communities. The Floodplain Management Section staff consists of the Floodplain Management Section Manager and State NFIP Coordinator, a floodplain engineer, floodplain management officer, and emergency management officer II. Staff perform numerous mitigation related activities including:

- training and technical support functions that are associated with managing statewide local government participation in the National Flood Insurance Program (NFIP)
- serving as a state cooperating technical partner in developing and updating floodplain flood insurance rate maps
- directly performing flood permitting for all state-owned construction projects

NFIP Participation

According to FEMA's Community Status Book, 88 communities have joined the National Flood Insurance Program since 2007, representing a 16.6% increase in participation. In addition, the number of

communities participating in the NFIPs Community Rating Service (CRS) has increased by 650% from 2 to 15 communities. **Table 7.4** provides additional details on progress made in NFIP participation.

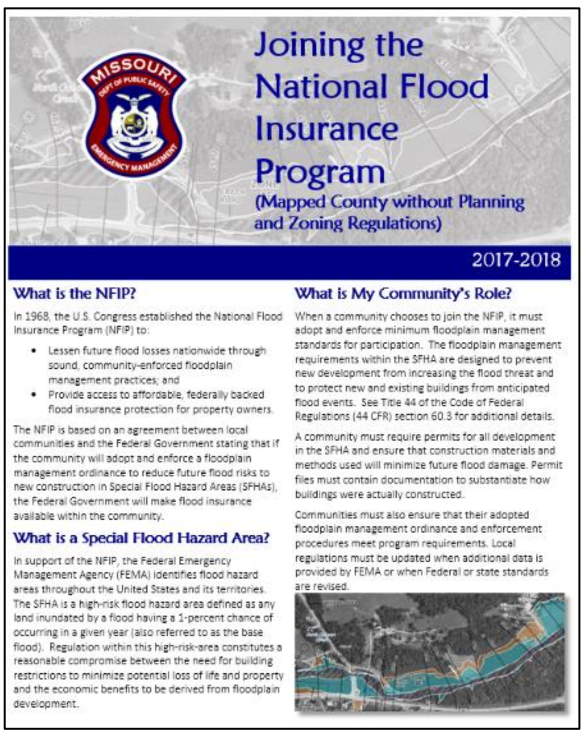
Table 7.4. Changes in NFIP Participation, 2007-2022

NFIP Participation	2007	2010	2013	2018	2022	15-Year Numerical Change	15-Year Percent Change
Total in Regular Program	584	604	652	672	681	97	16.6%
Total in Emergency Program	7	10	2	1	0	-7	100.0%
Total in NFIP	591	614	650	673	681	90	15.2%
CRS Communities	2	4	N/A	10	15	13	650.0%
Mapped Hazard Area, Not in Program	138	118	168	162	163	25	18.1%
Total Suspended	13	10	2	6	6	-7	-53.8%

Source: NFIP Community Status Book November 2022

The CRS program is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. The CRS program is aligned and integrated with hazard mitigation and local planning, through the award of activity points for protecting natural floodplains, preserving open space, regulating development, planning, and taking structural mitigation actions. SEMA's Floodplain Management Section administers the NFIP for the state of Missouri and coordinates with communities throughout the Risk MAP process and encouraging participation in the NFIP, as well as the CRS. Handouts covering the process to join the NFIP have been developed by SEMA to assist non-participating communities.

Figure 7.3. Sample NFIP Handout for Non-Participating Communities



Joining the National Flood Insurance Program

(Mapped County without Planning and Zoning Regulations)

2017-2018

What is the NFIP?

In 1968, the U.S. Congress established the National Flood Insurance Program (NFIP) to:

- Lessen future flood losses nationwide through sound, community-enforced floodplain management practices; and
- Provide access to affordable, federally backed flood insurance protection for property owners.

The NFIP is based on an agreement between local communities and the Federal Government stating that if the community will adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas (SFHAs), the Federal Government will make flood insurance available within the community.

What is a Special Flood Hazard Area?

In support of the NFIP, the Federal Emergency Management Agency (FEMA) identifies flood hazard areas throughout the United States and its territories. The SFHA is a high-risk flood hazard area defined as any land inundated by a flood having a 1-percent chance of occurring in a given year (also referred to as the base flood). Regulation within this high-risk-area constitutes a reasonable compromise between the need for building restrictions to minimize potential loss of life and property and the economic benefits to be derived from floodplain development.

What is My Community's Role?

When a community chooses to join the NFIP, it must adopt and enforce minimum floodplain management standards for participation. The floodplain management requirements within the SFHA are designed to prevent new development from increasing the flood threat and to protect new and existing buildings from anticipated flood events. See Title 44 of the Code of Federal Regulations (44 CFR) section 60.3 for additional details.

A community must require permits for all development in the SFHA and ensure that construction materials and methods used will minimize future flood damage. Permit files must contain documentation to substantiate how buildings were actually constructed.

Communities must also ensure that their adopted floodplain management ordinance and enforcement procedures meet program requirements. Local regulations must be updated when additional data is provided by FEMA or when Federal or state standards are revised.

Award Winning Staff

Karen McHugh, the State NFIP Coordinator, received national recognition in May 2022 as floodplain coordinator of the year. FEMA's Floodplain Management Division announced Ms. McHugh as the 2022 recipient of the Stacey Ricks Memorial NFIP State Coordinator of the Year award.

"We would like to extend our congratulations to Karen for this wonderful achievement," FEMA Region 7 Mitigation Division Director Cathi Sanders said. "Karen has been a great partner for many years and has significantly helped in better preparing Missourians for the impacts of flooding."

Ms. McHugh's effort as the NFIP Coordinator has helped make Missouri a leader in floodplain management, with the state being nationally recognized as one of only 10 states qualified in the Advanced Tier of FEMA's framework for management of federal funding to provide flood loss reduction measures. Currently, 681 Missouri communities participate in the National Flood Insurance Program.

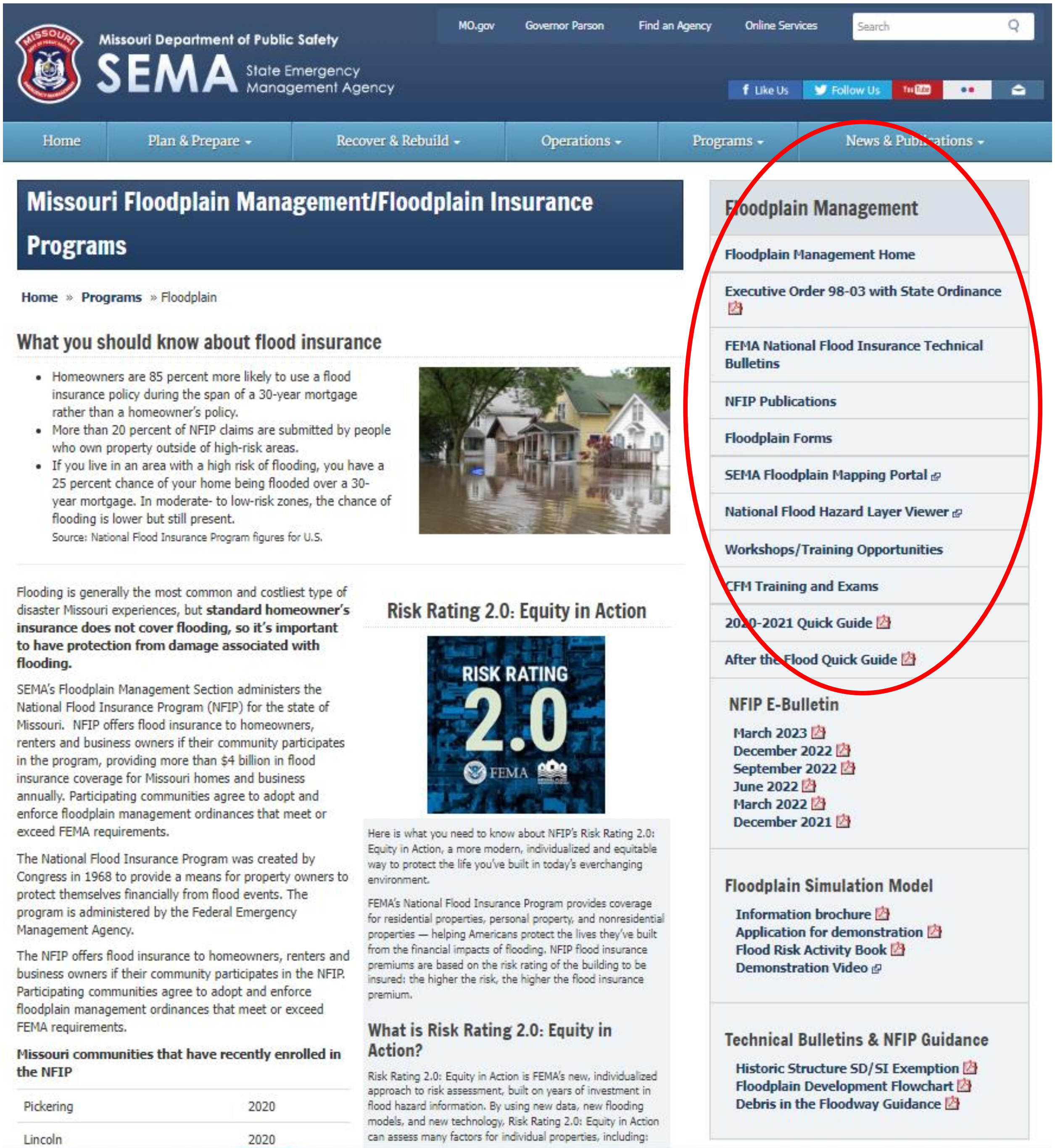
Ms. McHugh has been with SEMA's Floodplain Management team since 2007 and has been Missouri's NFIP Coordinator for more than five years, handling state floodplain development permit approvals, developing workshops for floodplain administrators, and evaluating all state development that impacts the Special Flood Hazard Area.

Technical Support

The Floodplain Management Section website presents information and data sources for helping communities with floodplain regulations and flood insurance information (See **Figure 7.4**). This all-encompassing toolbox of information includes:

- Executive Order 98-03 with the State Model Ordinance
- FEMA National Flood Insurance Technical Bulletins
- NFIP Publications – links to over 20 publications from NFIP Claims Handbook to Flood Insurance Agent Field Guide
- Floodplain Forms - Floodplain development forms are available including sample permits, engineering "no-rise" certificates, elevation certificates, and floodproofing certificates.
- SEMA Flood Mapping Portal
- National Flood Hazard Layer Viewer
- Workshop/Training Opportunities - Training workshops are outlined for the upcoming year along with registration applications.
- Certified floodplain manager workshops and exam resources are provided.
- The FEMA/SEMA Quick Guide is also available for reference and download. The Quick Guide helps local officials and citizens understand why and how Missouri communities must manage development in floodplains to protect people and property.
- An "After the Flood Guide" – this is a quick guide to help Missouri residents recovery smartly after a flood event.

Figure 7.4. SEMA Floodplain Management Section Website and Resources, 2023



Training

Training courses conducted by SEMA and the Floodplain Management Branch have included the following:

- **Tools of Floodplain Management** - a 2-day course designed for local floodplain administrators. It covers various important issues as well as day-to-day activities, incorporating updated NFIP

information and forms. This course is designed to provide basic knowledge of the National Flood Insurance Program (NFIP).

- **Substantial Damage Estimator (SDE)** - SEMA Floodplain staff has developed a workshop teaching all aspects of FEMA's SDE 3.0 program. Communities attending the workshop will receive tools to set up the SDE process. Workshop agenda topics include an inspection of a damaged building.
- **Lunch and Learn Series** - Since COVID travel restrictions began in March 2020, SEMA Floodplain Management Staff have worked to help floodplain administrators with continuing education opportunities. The Floodplain Management Staff have created 1-hour webinars where local floodplain administrators can listen during their lunch hours:
    - Basics of the NFIP
    - A Guide to Writing Proper Floodplain Development Permits
    - Preparing for Post-Disaster Responsibilities
    - Floodplain Questions & Answers

Cooperating Technical Partners (CTP)

SEMA and five local governments (City of Jackson, City of Lee's Summit, City of Springfield, Cass County and Greene County) participate in FEMA's Cooperating Technical Partners Program and collaborate on maintaining up-to-date flood maps and other flood hazard information. Participation allows CTP communities to develop more detailed maps by incorporating local data; receive streamlined FEMA customer service, access to existing FEMA data, and technical assistance; as well as, mentoring support, shared best practices, online resources, and free training to achieve more efficient and effective flood risk development. SEMA and the five communities applied for and were awarded CTP Grants for scoping, production, and post-preliminary processing and mapping of Missouri's floodplains.

Flood Permitting

In July 1997, Executive Order 97-09 was signed by the lieutenant governor authorizing SEMA to issue floodplain permits for any state-owned or leased development in a special flood hazard area. This is accomplished through coordination with the State's Office of Administration that oversees the State's owned and leased assets.

National Dam Safety Program

The National Dam Safety Program (NDSP) is a partnership of State agencies, Federal agencies, and other stakeholders that encourages and promotes the establishment and maintenance of effective Federal and State dam safety programs to reduce the risks to human life, property, and the environment from dam related hazards. Within Missouri this is implemented through:

- The Missouri Dam and Safety Reservoir Law of 1979 – this law established a dam safety program within MoDNR to ensure that dams in the state are constructed, maintained, and operated in a safe manner. This is accomplished by regulation of all nonagricultural, nonfederal dams of more than 35 feet in height and by providing technical assistance and informational resources to all dam owners.
- The Missouri Dam and Reservoir Safety Council – this council was also established by the Dam and Safety Reservoir Law of 1979. The Council's responsibilities are to adopt and amend technological guidelines, standard guidelines, rules, and regulations applicable to the permits, design, construction, maintenance operation, alteration, repair, reduction, removal, and natural physical changes that may occur to a dam or reservoir.
- The Dam and Reservoir Safety Program is leading an effort to develop Emergency Action Plans (EAPs) for regulated dams that will help save lives and reduce property damage during a dam safety emergency. EAPs increase preparedness by organizing emergency contact information

and evacuation procedures into an official document, and by providing enhanced communications between dam owners and local emergency managers.

Emergency Management Performance Grant Program (EMPG)

The Emergency Management Performance Grant Program (EMPG) plays an important role in the implementation of the National Preparedness System by supporting the building, sustainment, and delivery of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient Nation. For Missouri, the EMPG Program is administered by SEMA and provides resources for local government emergency management agencies for the sustainment and enhancement of all-hazard emergency management capabilities. SEMA also facilitates an EMPG working group to provide recommendations for priorities of EMPG funding and parameters of the grant. The EMGP working group includes 9 regional EMD representatives and 9 regional MOEMA representatives.

SEMA baseline requirements for local government emergency management agencies interested in EMPG include the following:

- Designate a 24/7 Emergency Operations Center (EOC)
- Maintain a Local Emergency Operations Plan (LEOP)
- Implement the National Incident Management System (NIMS)
- Complete FEMA/SEMA training requirements
- Participate in at least two (2) annual exercises
- Conduct or participate in an annual Training and Exercise Plan Workshop (TEPW)
- Utilize WebEOC during incidents, events and trainings
- Participate in Threat and Hazard Identification and Risk Assessment (THIRA) updates

Table 7.5 presents the total EMPG awards for 2014-2021 which includes funding for enhancing emergency management plans and programs, establishing and/or enhancing warning systems, emergency operations centers (EOC), and preparedness and training programs.

Table 7.5. EMPG Projects, 2014-2021

Project Type	Funding Amount
2014	**$6,253,047**
Develop/enhance plans, procedures, and protocols	$6,253,047
2015	**$6,907,016**
Establish/enhance emergency operations center	$6,570,000
Establish / enhance sustainable Homeland Security Planning Program	$337,016
2016	**$6,550,414**
Establish/enhance emergency operations center	$6,550,414
2017	**$9,317,353**
Develop / enhance homeland security / emergency management organization and structure	$1,563,464
Develop/enhance plans, procedures, and protocols	$203,268
Establish / enhance sustainable Homeland Security Planning Program	$25,686
Establish/enhance a terrorism intelligence/early warning system, center, or task force	$31,524
Establish/enhance emergency operations center	$4,493,094

Project Type	Funding Amount
Establish/enhance public-private emergency preparedness program	$221,953
Establish/enhance emergency operations center	$2,778,366
2018	**$6,271,156**
Adopt and implement NIMS to include integration of core concepts into plans and procedures	$98,500
Develop / enhance homeland security / emergency management organization and structure	$2,051,247
Develop/enhance plans, procedures, and protocols	$435,318
Establish / enhance sustainable Homeland Security Planning Program	$31,959
Establish/enhance emergency operations center	$796,229
Establish/enhance public-private emergency preparedness program	$330,067
Establish/enhance emergency operations center	$2,527,836
2019	**$3,987,091**
Adopt and implement NIMS to include integration of core concepts into plans and procedures	$3,687
Develop / enhance homeland security / emergency management organization and structure	$2,417,088
Develop/enhance plans, procedures, and protocols	$454,288
Establish / enhance sustainable Homeland Security Planning Program	$34,014
Establish/enhance emergency operations center	$834,031
Establish/enhance public-private emergency preparedness program	$243,983
2020	**$10,494,303**
Develop / enhance homeland security / emergency management organization and structure	$4,706,791
Develop/enhance plans, procedures, and protocols	$614,876
Establish / enhance sustainable Homeland Security Planning Program	$34,051
Establish/enhance emergency operations center	$962,828
Establish/enhance public-private emergency preparedness program	$283,027
Develop/enhance plans, procedures, and protocols	$3,892,730
2021	**$4,562,946**
Develop / enhance homeland security / emergency management organization and structure	$2,515,024
Develop/enhance plans, procedures, and protocols	$401,676
Establish / enhance sustainable Homeland Security Planning Program	$43,463
Establish/enhance emergency operations center	$1,310,036
Establish/enhance public-private emergency preparedness program	$241,213
Establish/enhance sustainable homeland security training program	$51,535
Total 2014-2021	**$54,343,326**

Source: FEMA Open datasets; https://www.fema.gov/openfema-data-page/emergency-management-performance-grants-v2

Mitigation is integrated with the EMPG program through FEMA/SEMA training requirements, including mitigation-related training, and data support for THIRA updates through sharing of the State Hazard Mitigation Plan risk assessment and results.

New Madrid Seismic Zone (NMSZ) Earthquake Preparations

Joint State of Missouri and Region VII Response Operations Plan (OPLAN), 2014

The joint OPLAN provides a concept of operation and the assignment of roles and responsibilities to local, state, and federal agencies to meet regional planning and response needs following a Moment Magnitude (Mw) Scale 7.7 earthquake within the NMSZ affecting the State of Missouri. Priorities for mitigation include approved mitigation projects in the declared disaster area, change to cost/benefit of the pre-approved project, and acknowledgement that repair costs will likely be substantial, exceeding 50-perent of the structure value.

Great ShakeOut Exercises

SEMA regularly participates in the annual Great ShakeOut earthquake drills. These exercises are designed to promote awareness and increase earthquake preparedness nationwide. The Great Central U.S. ShakeOut is a multi-state drill spanning much of the central United States. For the past 5 years, the State of Missouri has had an average of 426,258 participants, with 11,257 from State government.

Enhancements to the Earthquake Vulnerability Assessment

The earthquake portion of Missouri's previous 2013 State Hazard Mitigation Plan incorporated essential facility data from the Homeland Security Infrastructure Program (HSIP, 2011) and geological site classification and soil liquefaction characteristics from National Earthquake Hazards Reduction Program (NEHRP) and Missouri Department of Natural Resources. Two scenarios addressed earthquake vulnerability:

1) Annualized loss scenario
2) Scenario based on an event with a 2% probability of exceedance in 50 years to model a worst-case earthquake using a level of ground shaking recognized in earthquake-resistant design

For the 2018 Plan Update with additional funding through SEMA and the Central United States Earthquake Consortium (CUSEC), the risk assessment was enhanced to incorporate additional hazard data (groundwater depths and liquefaction data); and updated hazardous materials facilities; bridge information; and schools, fire and medical facilities to improve damage computations and further refine the vulnerability assessment to identify areas that may warrant further analysis or mitigation. The risk analysis summarizes the facilities most at risk based on Hazus estimates of damage probability and functionality. This summary may then inform local hazard mitigation plans and include recommendations for targeted mitigation and building-specific seismic safety analyses. These additionally analysis were brought forward into the 2023 plan update.

For the 2023 State Hazard Mitigation Plan, the vulnerability analysis combines and compares the efforts of FEMA's National Risk Index with state planning efforts. FEMA's National Risk Index results support the state planning analysis showing that dollar losses to be most significant in the southeastern portion of the State and in the urbanized areas near St. Louis. This is consistent with the southeastern portion of the State's proximity to the New Madrid Seismic Zone and the fact that the more developed areas in the region are likely to suffer the most building losses, particularly where there are large numbers of unreinforced masonry buildings.

7.2. Project Implementation Capability

Requirement §201.5(b)(2)(i) and (ii): [The enhanced plan must document] the State's project implementation capability, identifying and demonstrating the ability to implement the plan, including:

- *(i) Established eligibility criteria for multi-hazard mitigation measures.*
- *(ii) A system to determine the cost-effectiveness of mitigation measures, consistent with OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, and [a system] to rank the measures according to the State's eligibility criteria.*

Over the years, the State has developed and demonstrated mechanisms to implement mitigation plans and projects, including this Missouri State Hazard Mitigation Plan and the processes explained herein. SEMA has established criteria for projects, including multi-hazard considerations. SEMA uses FEMA's recommended benefit-cost analysis system to determine if potential mitigation activities are cost-effective and assigns priority to potential mitigation activities.

This section describes the Missouri State Hazard Mitigation Plan's eligibility criteria and procedures for determining the cost-effectiveness of mitigation measures. It also demonstrates how Missouri addresses the effectiveness and adequacy of the State's established eligibility criteria for multi-hazard mitigation actions; the effectiveness of its system for determining cost-effectiveness of those actions consistent with OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*; and the effectiveness of its approach to using cost-effectiveness as part of its eligibility criteria.

In addition, this section also describes how the State evaluates cost-effectiveness. The procedures for this evaluation are consistent with Missouri's Hazard Mitigation Grant Program Administrative Plan. It is now the responsibility of each local government submitting a grant application to perform a benefit-cost analysis (BCA) for projects. SEMA trains applicants on how to perform BCAs using FEMA software and then reviews the application submittals for accuracy and cost-effectiveness. SEMA also recruits the assistance of RPCs in providing BCA assistance to local jurisdictions.

Effectiveness is based on the fact that over 90 percent of projects submitted have been funded through deliberate efforts by SEMA staff, and potential losses were avoided in cases where a hazard affected a project site after its completion, e.g., significant savings were realized following the 1995 floods that succeeded the 1993 post-flood buyouts. SEMA's efforts to support subapplicants in the implementation of mitigation projects results in real risk reductions at the local level, protecting and preserving the lives, essential services, property and community tranquility within Missouri. Additionally, the national Multi-hazard Mitigation Council report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities* (2006), determined that mitigation projects, nationwide, are providing a return on investment (ROI) of 4-to-1. This report was updated in 2017 with the *National Hazard Mitigation Saves 2017 Interim Report.* This interim report presents study results demonstrating that mitigation grants funded through select federal government agencies for well-designed mitigation projects, on average, can save the nation $6 in future disaster costs, for every $1 spent on hazard mitigation. The report also demonstrates that, on average, investments in hazard mitigation measures that exceed provisions of the 2019 model building code can save the nation $4 for every $1 spent. The full report can be accessed through this link: https://www.nibs.org/projects/natural-hazard-mitigation-saves-2019-report. For more information about loss avoidance in Missouri, see **Section 7.4.2** Post-disaster Progress Assessment/Review of Mitigation Goals, Objectives, and Measures.

7.2.1 Process Used to Evaluate and Prioritize Mitigation Actions

This section explains the process used to evaluate and prioritize mitigation actions. Local jurisdictions are strongly encouraged to incorporate mitigation actions, based on established natural hazard risk assessments, into all proposed development projects and as improvements to existing projects.

Funding will always be an important issue when considering mitigation actions. Generally, mitigation funds are limited to the Hazard Mitigation Assistance grants. These programs are the Hazard Mitigation Grant Program, Flood Mitigation Assistance Program, and the Building Resilient Infrastructures and Communities (BRIC) Program. SEMA also uses FEMA's Public Assistance Program (Categories C-G) to implement mitigation activities. All these grant programs are non-disaster (annually funded) grant programs except the HMGP and Public Assistance Program which are post-disaster programs. To fairly and efficiently utilize these grant programs to achieve mitigation across the State, a sound process has been developed to evaluate and prioritize proposed mitigation actions so that limited grant funds are used most effectively in Missouri.

SEMA has the primary responsibility for reviewing and evaluating mitigation projects submitted by local jurisdictions. The SRMT may also be involved in the event of a large disaster. Broadly, SEMA uses the STAPLEE (social, technical, administrative, political, legal, economic, and environmental) criteria in evaluating mitigation projects and the following criteria to rank mitigation actions:

1) Flood mitigation projects (repetitive loss properties high priority)
2) Tornadoes and high wind mitigation projects
3) Earthquake mitigation projects
4) Other, not direct life safety

STAPLEE is used as a screening tool to determine if the project makes sense and is worthy of consideration and implementation. During the 2018 update, SEMA utilized a modified STAPLEE scoring system to evaluate all state mitigation actions that were identified in the mitigation strategy. See **Section 4.2.2** for a more detailed discussion.

Specifically, SEMA uses the following list of questions to help guide the distribution of mitigation project funds:

- What is the hazard to be mitigated?
- Does the applicant have a FEMA-approved mitigation plan?
- Does the project complement State and local mitigation goals and objectives identified in the mitigation plans?
- Is the hazard being mitigated a priority hazard in the applicant's mitigation plan?
- Is the project cost-effective based on FEMA's benefit-cost analysis module?
- Does the project have the potential to substantially reduce the risk of future damage, hardship, loss, or suffering that may result from a major disaster?
- Does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties?
- In the past, what mitigation efforts were undertaken by the applicant using local funds and initiatives and what were the outcomes?
- What is the applicant's disaster history?
- Are sufficient mitigation funds available to complete the project?
- Does the applicant have sufficient funds (if other funds are not available) to meet the local share of the project?
- Does the applicant have the capabilities to complete the project as submitted?
- Does the project independently solve a problem?

- Does the project have the potential to have a larger impact on the local and State mitigation program than other submitted projects?
- Does the project reduce impacts in an area experiencing growth and development pressures?
- Does the project have any negative impacts on neighboring communities?

With the implementation of Risk MAP, the mapped areas of mitigation interest (AoMI), and the tracking of mitigation actions, SEMA also places priority on projects that are identified within FEMA's Mitigation Action Tracker (or as a mitigation action in the hazard mitigation plan).

When funding comes from the Hazard Mitigation Grant Program (post-disaster funding), priority is given to mitigation projects related to the hazard that necessitated the disaster declaration and those jurisdictions included in the disaster declaration.

This plan does not differentiate or classify mitigation initiatives as primary or secondary. Mitigation initiatives will be evaluated and prioritized based on the criteria described above. Any mitigation project that is approved for funding is done so on the basis that it will benefit the community at large and, therefore, the State.

Information on this process is also included in **Section 4.2.2** Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions and **Section 5.3.2** Federal Project Grants.

As mentioned in **Section 7.1.3** Integration with USACE Mitigation Programs and Initiatives, SEMA worked with the Silver Jackets to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. Experts from a variety of State and Federal agencies and local partners came together to develop the buyout strategy to identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. Since the development of the strategy began in 2018 buyouts of residential properties increased from 18 projects to 30 projects in 2021, nearly doubling the number of projects and reduction in risk.

7.2.2 Eligibility Criteria for Multi-hazard Mitigation Projects

This section of the plan addresses the eligibility criteria for multi-hazard mitigation projects. The criteria listed in this section are the basic criteria for each type of project. These criteria may be modified based on any of the following issues:

- The specific disaster situation
- Location of affected areas
- Availability of funds
- Unique program requirements of the fund source
- Current State and/or local hazard mitigation priorities
- Number/type of mitigation projects submitted by local governments

All hazard mitigation projects submitted for HMGP funding consideration must meet the criteria outlined in 44 CFR 206.434. To meet FEMA's minimum hazard mitigation project criteria, the project must:

- Be in conformance with the hazard mitigation plan developed as a requirement of Section 322
- Have a beneficial impact upon the designated disaster area, whether or not located in the designated area
- Be in conformance with 44 CFR 9, Floodplain Management and Protection of Wetlands, and 44 CFR 10, Environmental Considerations

- Solve a problem independently or constitute a functional portion of a solution where there is assurance that the project as a whole will be completed (projects that merely identify or analyze hazards or problems are not eligible)
- Be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering resulting from a major disaster

The project must also meet the following State criteria:

- The project must complement existing or proposed State mitigation goals and objectives
- The project must complement existing or proposed mitigation goals and objects for the jurisdiction submitting the project
- The jurisdiction requesting the project must be able to complete the project as submitted
- The jurisdiction submitting the project must be able to meet any matching funds requirements (if required)
- The project must be able to make a bigger impact on the local and State mitigation program than other non-selected projects

The systems in place continue to work well; therefore, the 2023 update did not add or eliminate any of the eligibility criteria or alter the system for determining the cost-effectiveness of mitigation actions.

7.2.3 Eligibility Criteria by Mitigation Project Type

SEMA considers many types of projects to be eligible for mitigation, in particular the 11 “M” action categories identified in **Section 4.2** Mitigation Actions. All projects must be in conformance with at least one of these mitigation action categories. Flood mitigation projects continue to be the State’s highest priority, followed by tornado projects and finally earthquake projects. Among the actions that mitigate these hazards, those that provide for or protect life safety are given the highest priority.

Flood Mitigation Projects

In each type of flood mitigation project discussed below, homeowner participation must be voluntary and the homeowner must be able to prove ownership of the property involved in the project.

Property Acquisition

While buyouts are not the only mitigation projects considered and undertaken by the State and local governments, they have been the type of projects most frequently submitted and approved. Voluntary property acquisition is SEMA’s most successful, and usually most cost-effective, mitigation project, because the people and property are totally and permanently removed from flooding danger.

In general, SEMA works with local governmental entities to acquire and remove, elevate, relocate, or perform minor structural projects on privately owned residential structures and/or privately owned lots that are located in the floodplain and/or floodway. In addition to the requirements listed in the previous section, these projects must also meet the following criteria:

- The project chosen must independently solve or be a functional part of a solution to a problem that is repetitive or poses a significant risk to health and safety. The proposed solution must be the most practical, effective, cost-effective, and environmentally sound alternative among a range of alternatives that contribute to a long-term solution of the problem.
- Local governmental entities (and certain private nonprofit entities) must apply through the State, specifically SEMA, to FEMA for funding to perform a project or projects. The applications must specifically identify the properties to be included in the project or projects. All projects

must be proven cost-beneficial in accordance with a determination method that is acceptable to SEMA and FEMA (e.g., FEMA's benefit-cost analysis software).

- Local governmental/nonprofit entities must be in good standing in the National Flood Insurance Program (or have not yet been mapped) and otherwise eligible to receive federal funding. Nonfederal matches and all other federal grant requirements must be satisfied by the local entity, sometimes with monetary assistance from local property owners or possibly SEMA or the Missouri Department of Economic Development.
- Hazard Mitigation Grant Program, Building Resilient Infrastructure and Communities, and Flood Mitigation Assistance projects must be consistent with the Missouri State Hazard Mitigation Plan. Projects must also conform to 44 CFR 9, Floodplain Management and Protection of Wetlands, and 44 CFR 10, Environmental Considerations.
- Only local governmental/certain nonprofit entities, eligible special districts, or contractors representing these applicants may manage the project or projects. All projects must be managed in accordance with local, state, and federal ordinances, laws, and regulations. Individual property owners are not eligible to receive federal funds directly as an applicant or subapplicant and are not authorized to manage grant projects.

To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- The offer is based on pre-flood fair market value determined by a State board-certified appraiser or a post-flood sales contract value.
- Duplication of Benefits, Small Business Administration loans, and private mortgages must be satisfied from proceeds first.
- The buyout property must be demolished within 90 days of the closing.
- Local governmental entities, and certain nonprofit entities, must accept all buyout property titles, which are officially annotated to comply (in perpetuity) with federal open space deed restrictions. SEMA verifies that the appropriate restrictions have been put in place as part of the project closeout process.
- The buyout property becomes ineligible for any future federal disaster assistance, except possibly Federal Crop Insurance.

Elevation

Elevation is a voluntary option that may be used if it is the more cost-effective and desirable option in the long run (e.g., when the cost of the land is so high that a buyout is impractical). To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- The elevation project must be a practical, cost-effective, and structurally sound alternative (in compliance with local building code and zoning rules) that elevates the lowest floor to an elevation at or above the base-flood elevation (BFE, also equivalent to water surface elevation of the 1 percent or 100-year flood) or to an elevation that complies with local floodplain management regulations, if more stringent, by:
  - Extending the walls of the house upward and raising the lowest floor (where appropriate, such as within an area with a moderate or greater earthquake risk, SEMA adds multi-hazard stipulations, e.g., requiring shear walls as part of an elevation project).
  - Converting the existing lower area of the house to non-habitable space and building a new second story for living space.

- Lifting the entire house, with the floor slab attached, and building a new foundation to elevate the house.

- In A zones, property owners may elect to elevate buildings either on fill, an open foundation, or on continuous foundation walls that extend below the base-flood elevation. If continuous walls are used below the BFE, they must be equipped with openings that allow floodwaters to flow into and out of the area enclosed by the walls.
- Owners of substantially damaged homes in special flood hazard areas (SFHA) must be willing to relocate outside the SFHA, or voluntarily demolish the remnants of the house and build a new house on the same site with an elevated lowest floor at or above the BFE or at an elevation that complies with local floodplain management regulations, if more stringent.
- Alternatively, owners of substantially damaged houses in special flood hazard areas may elect to repair the house and elevate the lowest floor at or above the BFE or an elevation that complies with local floodplain management regulations, if more stringent, as part of the repair process.

Relocation

Relocation is a voluntary option that may be used if it is more practical/cost-effective or when the threat is so repetitive and/or severe that it is more advantageous to relocate a structure or structures, up to and including entire communities, entirely out of harm's way. Relocation is also an alternative to rebuilding following a declaration of substantial damage. To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- Structures relocated from acquired property must be placed entirely outside the 100-year floodplain
- Generally, structures must be relocated from acquired property within 90 days of closing
- Ownership of acquired property may not be conveyed to private citizens or entities; ownership may be conveyed to other public entities or nonprofit organizations with the approval of the State and FEMA
- Local governmental entities, and certain nonprofit entities, must accept all buyout property titles, which are officially annotated to comply (in perpetuity) with federal open space deed restrictions
- Any buyout property (i.e., any vacated lots acquired through the project) becomes ineligible for any future federal disaster assistance, except possibly Federal Crop Insurance

Floodproofing

Floodproofing is a voluntary option that may be most practical in limited areas. To be eligible to participate, the local governmental/nonprofit entity must agree that this measure will best remove the danger to the property. To be eligible, the following must apply:

- The property is in an area that is not subject to flash flooding
- Extensive cleanup normally is not required after a flood event
- One of the two floodproofing processes described below is the most advantageous measure to employ in the long run:
  - ***Wet floodproofing*** allows water to enter the structure, thereby equalizing pressure on walls and floors. Building contents such as furnaces and appliances are relocated out of reach of the floodwater.
  - ***Dry floodproofing*** is a process that uses waterproofing compounds, sheeting, or other impermeable materials to prevent floodwaters from entering the structure. To maintain

consistency with National Flood Insurance Program regulations, FEMA will not fund dry floodproofing of residential structures. FEMA may fund dry floodproofing of commercial structures, but protection must be up to at least one foot above the BFE or an elevation that complies with local floodplain management regulations, if more stringent.

Structural Mitigation Projects

Structural mitigation projects are most often infrastructure type projects sometimes associated with FEMA's post-disaster Public Assistance (PA) program. To be eligible for funding for structural mitigation projects, a jurisdiction and the project must meet all of the criteria of the federal/state public assistance program. Those criteria include, but are not limited to, the following:

- The project is required as a result of the declared event
- The project is within the designated disaster area
- The project is the legal responsibility of an eligible applicant

When these stipulations are met, a community can incorporate improvements into the repair or replacement of a damaged facility (e.g., replace a damaged culvert with a larger one, as long as it can be demonstrated to be technically feasible, cost-effective, and environmentally sound). There are other types of structural flood mitigation projects that can be promoted and encouraged in addition to those achieved through the PA program. For example, structural flood mitigation projects such as drainage improvements or low-water bridge crossings don't require a disaster declaration or damage to a specific facility.

Tornado Mitigation Projects

In addition to the relevant requirements for flood mitigation projects, tornado safe rooms and other similar mitigation measures that protect people from tornadoes and high winds, must comply with FEMA publications *Taking Shelter from the Storm: Building a Safe room Inside Your House* (320) and *Design and Construction Guidance for Community Shelters* (361). Only eligible construction-related costs will be reimbursed by FEMA.

Earthquake and Other Mitigation Projects

The majority of Missouri's approved mitigation projects have resulted from flood-related disasters. The recent frequency of tornadoes has made tornado safe room projects the next most frequent type of mitigation project sought. Other projects listed below may also be approved depending on the availability of funds, state and local priorities, and proof of benefit-cost and project submissions:

- Burial of power lines underground
- Structural seismic retrofit of undamaged critical facilities
- Nonstructural seismic retrofit of undamaged critical facilities (such as filming windows, strapping and bracing equipment, etc.)
- Development of educational programs and materials
- 5% State Initiative Projects

SEMA promotes a project identification framework from the NFIP's CRS. The following four types of mitigation categories emphasize flood solutions; however, they can also be applied to other natural hazards:

- Local Plans and Regulations
- Structure and Infrastructure Projects
- Natural Systems Protection
- Education and Awareness Programs

7.2.4 Pre-Project Determination of Cost-Effectiveness of Mitigation Measures

A key criterion for mitigation projects to be eligible for funding is that they must be cost-effective. If the project benefits are higher than the project costs, then the project is cost-effective. The purpose of this section is to address the process used by the State to determine the cost-effectiveness of mitigation actions. The only change to this process since the 2007 Mitigation Plan update is the utilization of FEMA's updated benefit-cost analysis software. Other than incorporating the updated software, changes to the process to determine cost-effectiveness of mitigation measures has not changed since the 2007 Mitigation Plan update.

In order to ensure a consistent approach in determining the cost-effectiveness of all mitigation projects, the State uses FEMA's BCA module and process, which is consistent with OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. Since this is the method developed and used by FEMA to determine the cost-effectiveness of a project, it is reasonable for the State to use the same method. A BCA assesses a mitigation project based on the project, hazard, and benefit data provided in a grant application. SEMA encourages applicants to pre-screen their proposed mitigation projects by using an upper-bound analysis, so an early determination of cost-effectiveness can be made. Upper-bound analyses are also used to identify projects that are not cost-effective.

SEMA organizes annual grant mentoring workshops, one for each grant cycle, to help local governments develop Hazard Mitigation Assistance subrecipient applications, benefit-cost analyses, and eGrant (Electronic Grant Application) applications. This includes the non-disaster (annually funded) grant programs of BRIC, FMA and the post-disaster grant program – HMGP. The workshops assist local governments and RPC planners with their applications. In October 2013 and May 2015, SEMA held two-day BCA workshops.

It is understood that a positive benefit-cost ratio (greater than one) does not necessarily guarantee that a hazard mitigation project will be approved. However, by applying project specific information to the benefit-cost analysis module it is possible to get a good look at the mitigation potential associated with a project. The results of this analysis can also help communities evaluate current and future mitigation projects and adjust their overall mitigation strategy accordingly.

The following information serves to summarize the three-step process for determining a mitigation project's cost-effectiveness. This process is used for determining the cost-effectiveness of all HMA project applications regardless of the type of mitigation measure.

1) Screen Project Application Data

The first part of the process is screening the project application to gather data related to cost-effectiveness. This includes economic, environmental, and engineering data. This data is often missing or limited. The amount of data available will determine the type of benefit-cost analysis used. The screening process involves three separate but related tasks. Each task is conducted simultaneously and is essential to developing an overall profile of the project before conducting the benefit-cost analysis.

- **Engineering Review**—This review, conducted by the applicant, establishes whether the project is feasible from an engineering standpoint and whether it will reduce damage as claimed. The reviewer may suggest changes to make the project more efficient in reducing damage and loss.
- **Environmental Assessment**—This part of the screening process alerts reviewers to any potential environmental concerns raised by the project.
- **Project Application Data Review**—This part of the screening process determines whether the application contains sufficient information and data for input into the benefit-cost model.

Table 7.6 shows the basic data that must be obtained from hazard mitigation applications before a benefit-cost analysis can be performed. This data is plugged into the benefit-cost module to determine whether the project is cost-effective or not. The examples below are key data used for analyzing flood, tornado, and earthquake hazard mitigation projects. Nevertheless, the same basic information and analysis is needed for mitigation projects related to any type of hazard.

Table 7.6. Key Data Needed for Analyzing Project Applications

Subject	Flood Project Data	Tornado Safe room Project	Earthquake Project Data
Hazard Data (often not included in application)	Flood insurance study data or historical flood data from application	Windspeed Zone	Seismic hazard data from a credible source
First Floor Elevation	Is this available from engineering surveys or can it be estimated from observed flood depths?	Not applicable	Not applicable
Scope	What problem does the project address? How vulnerable is the building, item, or area?	Same as flood	Same as flood
Cost	Is there a well-documented cost-estimate or only a rough estimate?	Same as flood	Same as flood
Useful Lifetime	How long will the project provide protection (mitigation) against damage and losses?	Same as flood	Same as flood
Economic Considerations	What is the square footage of the building? What are the replacement values of the building (or other facility) and contents?	Not applicable	Same as flood
Occupancy	Not usually applicable	Occupancy by hour	What are the levels of occupancy and visitors during various times throughout the day?
Function	What is the function of the facility and is it entirely or partially related to emergency response and recovery?	Same as flood	Same as flood
Damage Estimates—Before Mitigation	➢ What type of building is it? ➢ Why does damage occur? ➢ What is the historically-observed damage?	Not applicable (life safety mitigation)	➢ Same as flood ➢ Are engineering reports available that describe building/ facility seismic vulnerabilities?
Damage Estimates—After Mitigation	How effective will the mitigation project be in reducing future damage? (Reduced damage can be percent or dollar values)	Not applicable (life safety mitigation)	Same as flood

2) Conduct a Benefit-Cost Analysis

The second part of the process is determining which benefit-cost analysis tool to use. Ideally, the project application contains all the data needed. However, project applications often have incomplete or limited data. This is one of the main reasons that a streamlined process was developed to determine project cost-effectiveness without all data included. It is also the reason that federal, state, and local mitigation specialists must work closely together to ensure that all proposed mitigation projects are thoroughly reviewed and comply with the mitigation goals and objectives. For applications that don't have all required information, because some required information may not exist or be available, FEMA has developed several shortcuts that allow a benefit cost analysis to be conducted with limited information.

Screening the project data (step 1) helps determine which type of analysis to perform. If the project application data are limited or incomplete, then a benefit-cost analysis that uses limited data should be employed. If, however, the data in the project application are more or less complete, then a more robust method of analysis can be used.

A Benefit-cost analysis must be used for all cost-effectiveness determinations. At its most basic level, benefit-cost analysis determines whether the cost of investing in a mitigation project today (the "cost") will result in sufficiently reduced damage in the future (the "benefits") to justify spending money on the project. If the benefit is greater than the cost, then the project is cost-effective; if the benefit is less than the cost, then the project is not cost-effective. The benefit-cost ratio (BCR) is a way of stating whether benefits exceed projects costs, and by how much. It is figured by dividing the benefits by the costs. If the result is 1.0 or greater, then the project is cost-effective.

Example 1: The project cost is $1,000, and the value of damage prevented after the mitigation measure is $2,000. The BCR ($2,000/$1,000) is 2.0. Because the dollar value of benefits exceeds the cost of funding the project, and the BCR is greater than 1.0, the project is cost-effective.

Example 2: The project cost is $2,000, and the value of damage prevented after the mitigation measure is $1,000. The BCR ($1,000/ $2,000) is of 0.50. Because the cost of funding the project exceeds the dollar value of the benefits, and the BCR does not meet the 1.0 required for cost-effectiveness, the project is not cost-effective.

While these examples are oversimplifications, the process and the associated benefit-cost analysis calculations are basically the same for all mitigation projects. It is important to understand that benefit-cost analysis is essentially the same for each type of hazard mitigation project. The only differences are the types of data that are used in the calculations. The types of data depend on whether the project is for floods, tornadoes, or earthquakes.

Three approaches are used to determine a project's benefit-cost ratio: lower-bound analysis, upper-bound analysis, and best estimate. The lower-bound and upper-bound methods are used in many cases to make final determinations of cost-effectiveness when there is limited data. In other cases, quick screening analysis with these approaches yields inconclusive results and additional data and screening may be required. Best estimate analysis produces the most accurate results.

Lower-Bound Analysis

Lower-bound analysis is a powerful tool that can demonstrate that projects are cost-effective even if the available data is not complete. A project's cost-effectiveness can sometimes be determined by using only one or two key pieces of data. The lower-bound analysis was developed with this in mind.

The lower-bound analysis considers only some of a project's benefits (those that are the most important or those for which data exist) and ignores other benefits that may be difficult to estimate or for which data may not be available. In other words, this analysis purposely uses only a few pieces of information

and undercounts, or ignores other benefits that may be gained by implementing the project. If results indicate that a project is cost-effective, then no further analysis is needed and no additional data has to be collected.

Lower-bound analysis at a glance:

- It should be used when data is incomplete
- It can determine that a project is cost-effective
- It cannot determine that a project is not cost-effective
- It uses data for one or two significant benefits

Upper-Bound Analysis

If a lower-bound analysis shows that a project is not cost-effective, then the next step is an upper-bound analysis. Sometimes an upper-bound analysis is used if, at first glance, the project appears not to be cost-effective. Like lower-bound analysis, upper-bound analysis relies on limited project data. Upper-bound analysis, however, also uses professional judgment to estimate which input data produce the highest reasonable benefits.

It is extremely important to note that upper-bound analysis cannot determine if a project is cost-effective because it relies on the highest reasonable estimate of benefits. An upper-bound analysis can only determine whether the project BCR is less than 1.0 and thus not cost-effective.

Upper-bound analysis at a glance:

- It can only determine that a project is not cost-effective
- It is used as the next step if the lower-bound analysis is negative (not cost-effective)
- It is used if a project appears, at first glance, unlikely to be cost-effective
- It uses the highest reasonable estimate of benefits for a project
- It analyzes as many inputs as possible, assigning the highest reasonable value to each

Best Estimate Analysis

A best estimate analysis is used when the project application data is complete, or almost complete. This analysis provides a more accurate BCR than either lower- or upper-bound, because it considers more data in the analysis. As discussed earlier, in many cases lower-bound or upper-bound analysis can provide firm decisions about cost-effectiveness without requiring as much data as a best estimate analysis.

A best estimate analysis can determine if a project is either cost-effective or not, because all significant data are considered. Because this method of benefit-cost analysis provides the best estimate of cost-effectiveness, it can be used to rank or set priorities among competing projects. Neither lower-bound nor upper-bound analysis are used to rank or set priorities among projects. They do not consider enough data to determine accurate BCRs; they only produce "bounds" on BCRs (i.e., BCR > 1.0 or BCR < 1.0).

Best estimate analysis at a glance:

- It should be used when the project application data is complete, or almost complete
- It produces a more accurate analysis than lower-bound and upper-bound analyses
- It determines whether a project is cost-effective or not cost-effective
- BCR can be used for ranking or setting priorities among projects

3) Review the Results of Benefit-Cost Analysis

The final step of the review process is to determine whether a project is cost-effective or whether further analysis is required. There are three possible outcomes to a benefit-cost analysis: the project is deemed cost-effective (BCA > 1.0), the project is deemed not cost-effective (BCA < 1.0), or additional data may be required.

Typically, if the project is cost-effective as determined by a lower-bound or best estimate analysis, then no further analysis or additional data collection is required. Then the application moves to the next level in the funding process. If the project is not cost-effective as determined by an upper-bound or best estimate analysis, then no further analysis or additional data collection is required and the project is rejected. In some cases, additional information may be requested, or the applicant may be shown how the mitigation effort can be redirected. In general, for the Pre-Disaster Mitigation grant program, it is an advantage to maximize benefits (e.g., BCA > 1.0) to make the application more competitive.

If the cost-effectiveness of a project cannot be determined, then additional data must be collected. It is important to recognize that only the minimum data necessary to reach a decision on project cost-effectiveness must be collected. In many cases, the collection of one or two pieces of information is sufficient to reach a decision. A complete analysis is conducted for those relatively few cases where the BCA is close to 1.0.

4) Alternative Cost-Effectiveness Methodology

As previously noted, a project is cost-effective when the Benefit-Cost Ratio (BCR) is 1.0 or greater at a 7% discount rate. A discount rate is the interest rate used in calculating the present value of expected yearly benefits and costs. To reduce barriers and ensure federal funding can reach more communities, for the FY2022 application cycle FEMA adjusted how it calculates Benefit-Cost Analysis for BRIC and FMA grant programs. FEMA will now consider a mitigation project cost-effective if, when using the 7% discount rate, the BCR is at least 0.75 or greater. When using the 3% discount rate, FEMA will consider projects cost-effective if the BCR is at least 1.0 or greater. Projects must also benefit disadvantaged communities and address climate change.

These changes encourage the use of climate-informed science to make our communities safer and reduce disaster suffering. Moreover, the modification is part of our commitment to a “people first” approach to make our entire nation resilient in the face of climate change.

7.3. Program Management Capability

Requirement §201.5(b)(2) (iii A-D): [The enhanced plan must demonstrate] that the state has the capability to effectively manage the HMGP as well as other mitigation grant programs, [and provide] a record of the following:

a) Meeting HMGP and other mitigation grant application timeframes and submitting complete, technically feasible, and eligible project applications with appropriate supporting documentation;

b) Preparing and submitting accurate environmental reviews and benefit-cost analyses;

c) Submitting complete and accurate quarterly progress and financial reports on time; and

d) Completing HMGP and other mitigation grant projects within established performance periods.

Requirement §201.4(c)(5)(i): [The standard state plan maintenance process must include an] established method and schedule for monitoring, evaluating, and updating the plan.

Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

7.3.1 State Capability for Hazard Mitigation

Since Section 322 of the Disaster Mitigation Act of 2000, FEMA has provided for a significant increase in Hazard Mitigation Grant Program (HMGP) funding available to the State. In addition, since the Disaster Recovery Reform Act of 2018 and development of the Building Resilient Infrastructure and Communities (BRIC) program to FEMA is increasing investments in mitigation projects which address National Public Infrastructure Pre-Disaster Hazard Mitigation. With these programs, it is critical that the State demonstrate its ability to manage the HMA grants and its commitment to mitigation.

The following factors were initially developed by FEMA for considering a state for “managing state” status. Missouri meets all of these requirements and was initially designated as a “managing state” for hazard mitigation in February 2001. SEMA’s HMA grant management performance from 2018 through 2022 is also summarized in **Table 7.7.**

Past Performance of the State

Grant Application Submittals

Following receipt of letters of notification, SEMA reviews subapplicant HMA proposals that include a brief project description, location, work schedule, cost estimate, and explanation of how the project solves a problem. Initial eligibility is determined by SEMA (See **Section 7.2.2**) and eligible project applications are then accepted.

Upon receipt of each full application the Mitigation Management Section reviews the submitted documents to ensure that adequate information has been provided and that the projects will meet the minimum criteria as defined by 44 CFR Part 206.434. Priority is given to flood mitigation, tornado/severe wind, and earthquake mitigation projects located in the declared counties.

Following the review and any site visits deemed necessary, the Mitigation Management Section conducts final preparation of the selected applications for submittal to FEMA. SEMA submits selected applications to FEMA Region VII in the order that they are received and reviewed. SEMA will stay up to date on the submittal process, as FEMA is moving away from the previous process using the National

Emergency Management Information System (NEMIS). FEMA Grant Outcomes (FEMA GO) is the new system to apply, track, and manage all disaster and non-disaster grants issued after FY2020.

Grant Application Selection and Prioritization

In the previous years, a committee, appointed by the Governor, selected, coordinated, and managed the residential buyout projects of 1993, 1994, and 1995. The wisdom in this multi-agency approach can be found in the results. Six months after funding became available, all projects were approved and one project was completed. Similarly, after flooding in 2008, the Governor called together a steering committee to re-emphasize flooding awareness with a subcommittee comprised of state agencies with resources for flood response and mitigation. For additional description of successful multi-agency coordination, see the description of the Silver Jackets Program that followed the 2008 flood event in **Section 7.5.1** Mitigation Success.

As noted in **Section 7.1.3**, in 2017 SEMA, other agencies, and Silver Jackets Program developed a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy identified a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy will rank the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state.

Smaller mitigation projects are coordinated with the agencies responsible for environmental approvals, partial funding, or other projects with similar objectives, stakeholders, or locations, such as the Departments of Economic Development, Conservation, Natural Resources, and Transportation; the U.S. Army Corps of Engineers; and others as the situation dictates. This practice will continue with a more formal body used in the event that large project opportunities are presented.

Accurate Environmental Reviews and Benefit-Cost Analyses

SEMA and State agency partners work together to prepare environmental documentation and conduct benefit-cost analyses. This is further proven by the roles of the Department of Natural Resources and the Department of Conservation in providing environmental documentation to ensure compliance with the National Environmental Policy Act. The Department of Natural Resources' State Historic Preservation Officer (SHPO) coordinates with SEMA on all mitigation projects to ensure that any and all historic preservation concerns are recognized and addressed. The Department of Conservation is consulted to ensure compliance with the Endangered Species Act.

Until recently, SEMA performed benefit-cost analyses for all hazard mitigation grant applications. Since the 2004 plan, the RPCs and the local governments have all been offered training on FEMA's BCA software at least once annually and many are now capable of performing the required benefit-cost analysis to be submitted with HMA grant applications. SEMA continues to provide technical assistance regarding BCAs, but only for communities that do not have the capability to do it themselves. SEMA also reviews all benefit-cost analysis results during the project eligibility time frame.

Quarterly Progress and Financial Reports

Missouri's Hazard Mitigation Grant Program (HMGP) Administrative Plan, quarterly reporting system, and HMGP applications have all been used as models for other states as well as FEMA headquarters. The Hazard Mitigation Grant Program Administrative Plan developed by SEMA in 1995 was one of the first procedural plans developed that addressed additional elements not required by the Code of Federal Regulations. In addition, Missouri's standard HMGP buyout application and quarterly reports were requested by FEMA headquarters to use as the National Emergency Management Information System standard.

Missouri consistently provides quarterly reports on time. Missouri maintains a record for meeting all HMA grant application timeframes, utilizing allowed and approved extensions only when necessary. When extensions to timeframes are deemed necessary or critical, the State has consistently requested such extensions prior to lapse of initial timeframes.

Grant Project Completion

Prior to 2002, Missouri used mitigation funding for buyouts, elevations, and relocations; however, the nature of hazards in Missouri and types of mitigation projects broadened. Flood mitigation remains a priority, but changes in threats required SEMA to broaden its perspective in mitigation projects. Since the last State plan update in 2018, the State has successfully completed 18 flood buyout projects, 62 tornado safe room projects, two low water crossing projects, 10 siren and generator projects, and five mitigation planning projects. All projects were completed within the performance period including all financial reconciliations.

Table 7.7. Summary of HMA Grant Management Performance

HMA Grant Management Performance Activities	Enhanced Plan Review Element	FY2018	FY2019	FY2020	FY2021	FY2022
E2. Is the state maintaining the capability to meet application time frames and submitting complete project applications?						
a. All applications were complete and submitted by the end of each program's respective application period.	E6.a	100%	100%	100%	100%[1]	100%
b. All applications were entered into FEMA's electronic data systems (i.e., the National Emergency Management Information System [NEMIS], eGrants, and/or FEMA Grants Outcomes [FEMA GO]).	E6.b	100%	100%	100%	100%	100%
c. Complete Minimum Criteria Checklists for Project Subapplicants or equivalent documentation were prepared for all subapplications.	E6.c	100%	100%	100%	100%	100%
d. All applications were determined to be complete by FEMA within 90 days of submittal or selection for further review, or after the first request for information response.	E6.d	100%	100%	100%	100%	100%
E3. Is the state maintaining the capability to prepare and submit accurate environmental reviews and benefit-cost analyses?						
a. All applications and amendments were determined to be complete by FEMA within 90 days of submittal or selection for further review, or after the first request for information response, including all data requested by FEMA to support cost-effectiveness determinations and EHP compliance reviews.	E7	100%	100%	100%	100%	100%
E4. Is the state maintaining the capability to submit complete and accurate quarterly progress and financial reports on time?						
a. All progress reports were complete and submitted on time. Information in reports accurately described grant activities, including data related to the completion of	E8.a	100%	100%	100%	100%	100%

HMA Grant Management Performance Activities	Enhanced Plan Review Element	FY2018	FY2019	FY2020	FY2021	FY2022
individual property acquisitions.						
b. All Federal Financial Reports (FFR) Standard Form (SF) SF-425 were submitted on time. Information in reports must accurately described grant activities as described in the HMA Guidance.	E8.b	100%	100%	100%	100%	100%
c. State consistently complies with the Financial and Program Management Standard requirements described in 2 CFR §§ 200.300 to 200.309.	E8.c	100%	100%	100%	100%	100%
E4. Is the state maintaining the capability to complete HMA projects within established performance periods, including financial reconciliation?						
a. All work as part of HMA subawards was completed by the end of the period of performance as described in the HMA Guidance. All extension requests were complete, on time and with adequate justification.	E9.a	100%	100%	100%	100%	100%
b. There were no major findings on the last single audit obtained by the state related to HMA programs.	E9.b	✓	✓	✓	✓	✓
c. All grant closeout activities and documentation, including financial reconciliation, were completed within 120 days from the end of the award performance period.	E9.c	100%	100%	100%	100%	100%
d. Actual expenditures have been documented and are consistent with SF-424A or SF-424C.	E9.d	100%	100%	100%	100%	100%

[1] For DR-4612, SEMA did not meet the application deadline. DR-4612 funding was not utilized due to miscommunication of application due dates. To ensure this does not happen with future opportunities, Missouri will list the application and Period of Performance (POP) due dates and send them to the Missouri FEMA Liaisons for confirmation periodically. The application and Period of Performance (POP) dues dates will also be listed in monthly meetings between SEMA and FEMA.

Adequate and Experienced Staff at Both the State and Regional Level

The Mitigation Management Section's permanent full-time staff includes the state hazard mitigation officer, the deputy state hazard mitigation officer, two hazard mitigation specialists, and one clerical assistant. The hazard mitigation specialists provide technical assistance to local jurisdictions regarding planning issues and mitigation project development. All staff have attended FEMA-training on local Hazard Mitigation Planning. In addition, the State uses an area coordinator system for emergency planning. These nine area coordinators have been instrumental in dealing with communities on a one-on-one basis.

All staff members are proficient in their technical skills. To ensure consistency and smooth transitions, great care has been taken to ensure that all staff members are cross-trained and receive appropriate FEMA training. The Mitigation Management Section has directly administered over $100 million in HMA grant funding since 1993. All current staff members have received formal benefit-cost analysis training. Three staff members have taken the FEMA grants management and NEMIS training. All staff members

have attended several all-hazard mitigation workshops or state hazard mitigation officer training courses.

Newly hired staff will receive direct training either from existing staff or through partnerships with other state hazard mitigation officers and will attend formal FEMA training as appropriate. See Section 6 for further descriptions of staff responsibilities.

Commitment to Training by the State and FEMA

Training for local units of government before and following an HMA award is ongoing. Formality depends on the needs of the community. Currently, SEMA offers annual training on basic mitigation planning, and technical assistance for grant applications, and additional training is offered as needed.

State and Regional Relationship

The relationship between the State and FEMA Region VII has always been maintained in an open, professional manner.

Demonstrated Relationship between the State and Local Governments

Throughout the extensive voluntary buyout program and for all mitigation projects, the State has operated on a basic principle—centralized planning with decentralized execution. To the extent that local governments can manage projects, they are allowed to do so. However, compliance with established procedures, priorities, and “safe guard measures” is required. Local governments have been vocal in their enthusiastic support for this approach. SEMA is routinely told that they provide local governments with exactly what they need to be successful.

7.4. Assessment of Mitigation Actions

Requirement §201.5(b)(2) (iv): The enhanced plan must document the system and strategy by which the state will conduct an assessment of the completed mitigation actions and include a record of the effectiveness (actual cost avoidance) of each mitigation action.

This section explains how the State assesses the effectiveness of mitigation projects, both pre- and post-disaster. Also explained is how SEMA has improved their ability to monitor and track each completed project and potential losses avoided since development of the original plan in 2004.

7.4.1. Annual Progress Assessment/Review of Mitigation Goals, Objectives, and Measures

In order for any program to remain effective, the goals and objectives of that program must be reviewed periodically. The Missouri State Hazard Mitigation Plan is reviewed annually. This provides the simplest, direct and ongoing methodology for assessing and reviewing mitigation goals, objectives, and actions. At a minimum, the review addresses the following issues:

- Are the established goals and objectives realistic? (Take into consideration available funding, staffing, and state/local capabilities, and the overall state mitigation strategy.)
- Has the State clearly explained the overall mitigation strategy to local governments?
- Are proposed mitigation projects evaluated based on how they help the State and/or local government meet their overall mitigation goals and objectives?
- How have approved mitigation projects complemented existing State and/or local government mitigation goals and objectives?
- Have completed mitigation projects generated the anticipated cost avoidance or other disaster reduction result?

For the 2023 update, the SRMT reconsidered the validity of the goals and objectives of this mitigation plan and of the State mitigation program. This is detailed in **Section 4.1** Hazard Mitigation Goals and Objectives. The SRMT decided to maintain the current goals and objectives as they are considered to remain valid and applicable in guiding the mitigation strategy of the State.

The overall mitigation strategy is clearly communicated to local governments throughout the year and is an ongoing process. The strategy is explained through SEMA mitigation training and workshops (HMA, mitigation planning) and at annual meetings of the Missouri Emergency Preparedness Association, the Missouri Floodplain and Stormwater Managers Association, and the Missouri Association of Councils of Governments.

In order to earn SEMA approval, mitigation projects must complement the overall mitigation strategy of the State as well as the applicable local government. This is included in the list of questions to help guide the distribution of mitigation project funds detailed in **Section 5.3.2** Federal Project Grants.

How SEMA determines whether or not completed mitigation projects generate the anticipated loss avoidance or other disaster reduction result is explained in **Section 7.4.2** Post-disaster Progress Assessment/Review for Mitigation Goals, Objectives, and Measures.

Finally, the Mitigation Management Section of SEMA furthers this programmatic progress assessment through the ongoing tracking of:

- Mitigation activities during the past year

- Mitigation grants in progress, including
  - Affected jurisdiction
  - Brief description of the project
  - Project cost
  - Source of funding
  - Summary of project status (percent complete)
- Executed mitigation grant support contracts
- Floodplain management activities during the past year, including
  - NFIP statewide statistics
  - NFIP training activities conducted

All of the above information is captured in SEMA's fiscal year annual report.

It may be difficult to determine the actual loss avoidance and effectiveness of many mitigation projects during project development. Initially, the potential impact of mitigation projects and initiatives can only be estimated. However, based on past experience with similar projects, SEMA can make an educated determination as to the potential for success of the proposed mitigation project.

Based on the results of this information and the annual review, the State considers making adjustments to its goals, objectives, and actions to meet the current and future mitigation needs of the State and its local governments.

7.4.2. Post-disaster Progress Assessment/Review of Mitigation Goals, Objectives, and Measures

Following a hazard event, SEMA mitigation staff query local officials to document how mitigation actions instituted in the affected areas reduced the amount of damage or loss of life that could have resulted from an event. SEMA has updated this query process and formalized loss avoidance documentation through a newly-developed web-based tool which follows the loss avoidance methodology developed by FEMA.

FEMA developed the loss avoidance methodology to evaluate the effectiveness of mitigation projects based on the analysis of actual events. This methodology can be applied to the mitigation of any type of natural hazard. Losses avoided are determined by comparing the damage that would likely have been caused by the same storms without the project (Mitigation Project Absent, MP_A) with damage that actually occurred with the project in place (Mitigation Project Complete, MP_C). There are three phases of the general methodology for loss avoidance studies:

1) Initial Project Selection
2) Project Effectiveness Analysis
3) Loss Estimation Analysis

Phase 1 focuses on the selection of the completed project area to be included in the loss avoidance study. Structures are screened based on the availability of data required for completion of the study. This includes actual project costs, construction completion dates, first floor elevations, structure location information, and structure information, including the type, basement information, number of floors, square footage, and building replacement value. Structures with adequate data advance to Phase 2.

Phase 2 includes a storm event analysis, to determine whether a post-construction storm event is severe enough to have caused damage if the project had not been completed (MP_A scenario), and a hazard

analysis, to determine the impact of the hazard event (e.g., depth of flooding) at the mitigation project location.

Phase 3 includes two steps. First, an economic evaluation of the project scope is completed for both the MP_A and MP_C scenarios for each hazard event analyzed. The difference between the total losses for the two scenarios is calculated and losses avoided are determined. Second, the return on investment (ROI) is assessed by comparing the losses avoided to the total project investment.

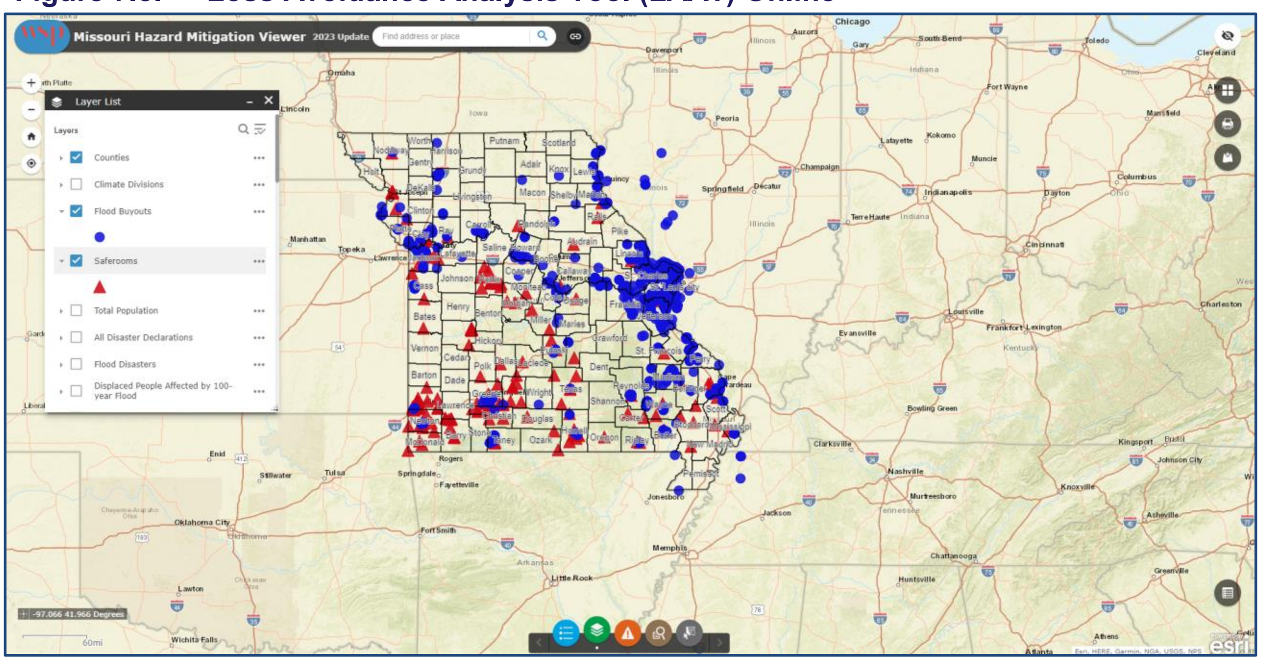
For the 2018 State Plan Update, SEMA developed a web-based, loss avoidance analysis tool (LAAT) to assist SEMA staff and local officials collect and store the data necessary to complete a loss avoidance study following a hazard event.

Loss Avoidance Analysis Tool (LAAT)

The web-based, loss avoidance analysis tool (LAAT) is a database of the structural data necessary to complete Phase 1 of a loss avoidance study and is a data collection tool for the storm event data necessary to complete Phase 2 of a loss avoidance study. The LAAT website, originally an independent site, has been integrated with the 2023 State Plan Viewer and can be accessed here: https://bit.ly/MoHazardMitigationPlanViewer2023 . A User Guide has been prepared for the LAAT website and is included as Appendix E.

Step 1: Initial Project Selection – For all completed mitigation projects within the State, the LAAT database has been populated with project details as included in the approved grant application and project closeout documents. This includes actual project costs, construction completion dates, first floor elevations, and structure information. **Figure 7.5** presents the LAAT website showing the tornado safe room locations in blue and residential buyout locations in red.

Figure 7.5. Loss Avoidance Analysis Tool (LAAT) Online



Each mitigation project has also been spatially located based upon the street address or latitude/longitude, as either obtained from the project grant application or field located with GPS. Efforts to map completed buyouts prior to 2002 have proven difficult because communities have

combined parcels and lots into combined open spaces, streets and addresses no longer exist (as a result of the buyouts), and legal property descriptions are not accurate enough to pinpoint precise locations.

Those mitigation projects with limited structural or location data are included in the LAAT database, but will not move forward to Phase 2 and be utilized in a loss avoidance study.

The LAAT database may be updated at any time to include additional project information. For future mitigation projects, the structure data necessary to complete Phase 1 of a loss avoidance study will be entered by SEMA staff upon project completion and closeout.

Step 2: Project Effectiveness Analysis – Because a loss avoidance study measures benefits of a completed project based upon an actual event, the local official will be tasked with completing the storm event data collection form following a hazard event within their community or SEMA staff can add this information easily to any reports resulting from disaster declarations. The user can spatially select those mitigation projects within the hazard event area and do a simple export to show the calculated loss avoidance. **Figure 7.6** displays the Operational Tools available on the website. **Figure 7.7** shows the Add Data Tool options. Users can either upload a project area shapefile or simple draw an area of interest to use for the analysis. The user can also share the data from the analysis with others as shown in **Figure 7.9**.

Figure 7.6. LAAT Website – Operational Tools

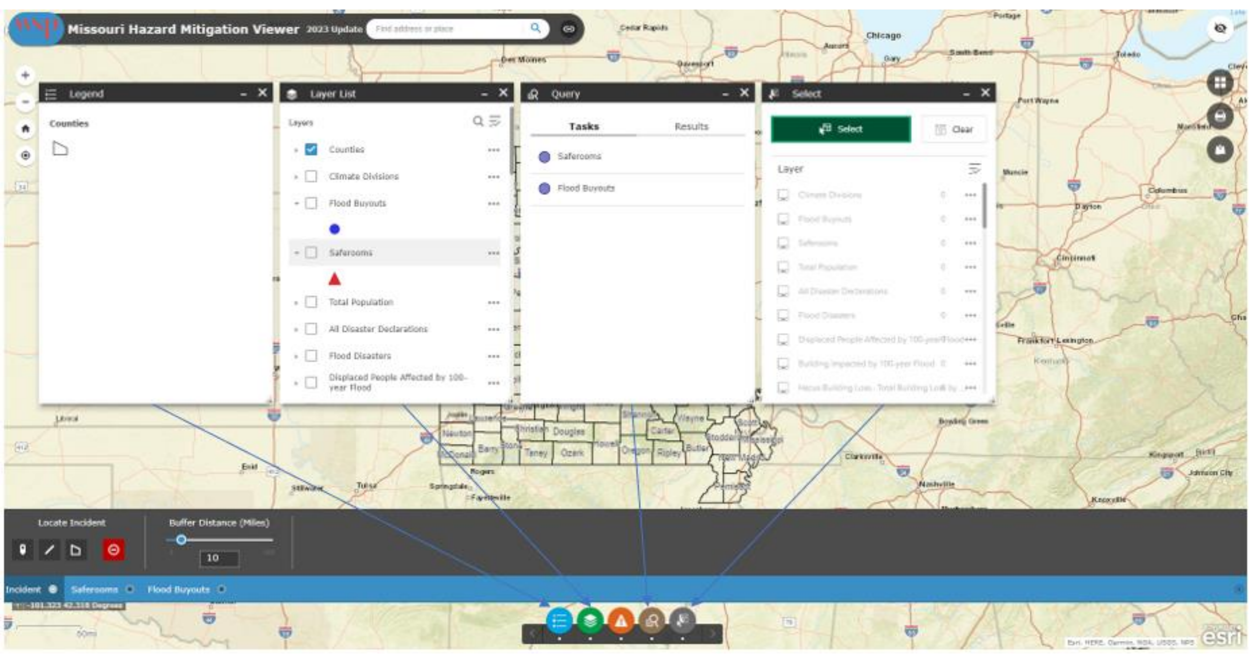
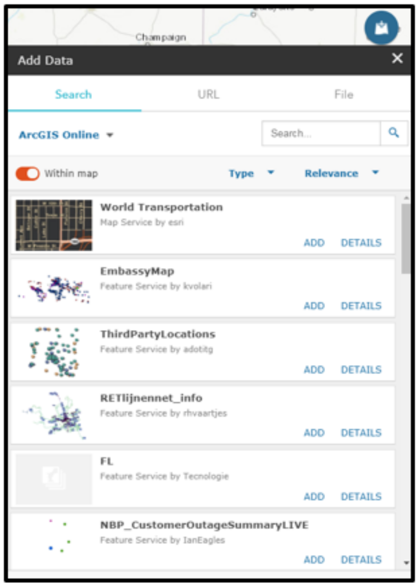
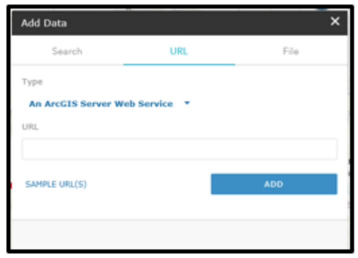


Figure 7.7. LAAT Website – "Add Data" Tool

1) From ArcGIS Online



2) From another Public Location/Agency



Add Data from following:

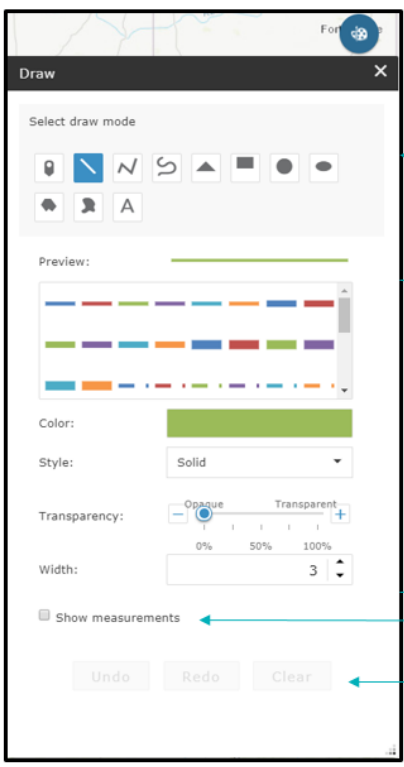
- ArcGIS Server Web Service
- WMS OGC Web Service
- KML
- GeoRSS File
- CSV File

3) Project and/or Personal Data

Add Data from Local Computer by Drag/Drop or Browse to Location.

Files Include:
- Shapefile
- CSV
- GPX
- GeoJson

Figure 7.8. LAAT Website – "Draw" Tool



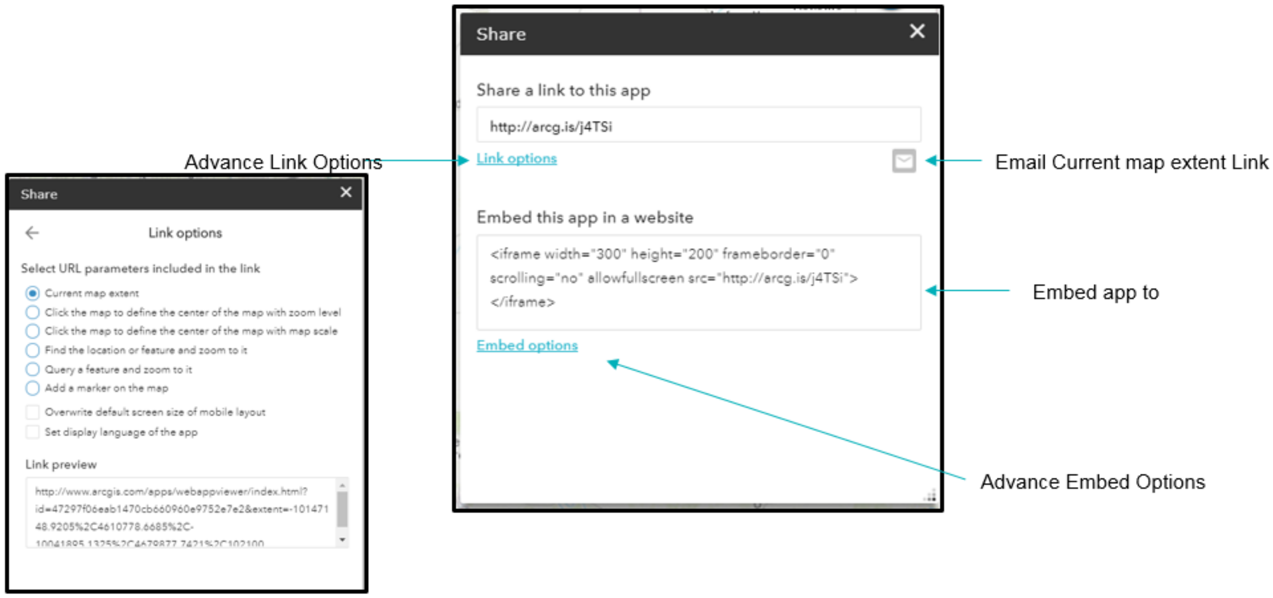
Select Shape (Point, Line, Polygon, or Text)

Options for Shape

Approximate Measurement tool based on shape chosen

Options to set drawing

Figure 7.9. LAAT Website – "Share" Tool



Step 3: Loss Estimation Analysis - This final phase consists of estimating losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. The two major tasks in Phase 3 are (1) calculating losses avoided and (2) calculating the return on investment. This can now be done "on the fly" with the LAT by utilizing the Query Tool as shown in **Figure 7.10**.

This information and the results of completed loss avoidance studies will be incorporated into mitigation success stories to aid in the assessment of the current and future goals, objectives, and actions by simply exporting the data in the needed format using the Incident Analysis Tool shown in **Figure 7.11**.

Figure 7.10. LAAT Website – "Query" Tool

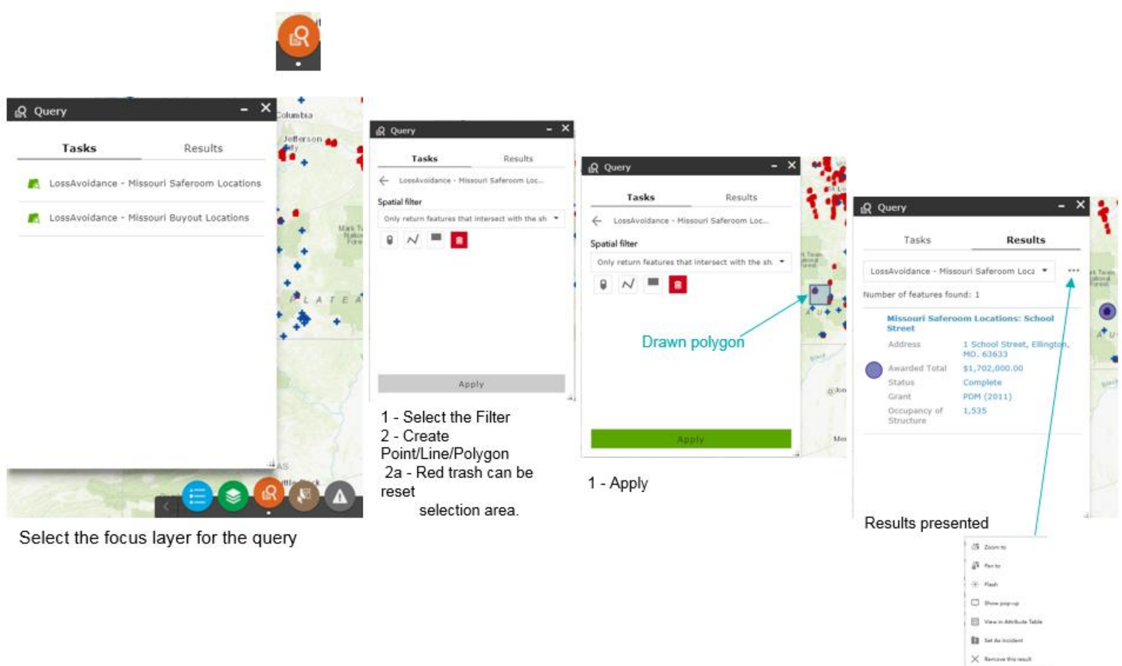
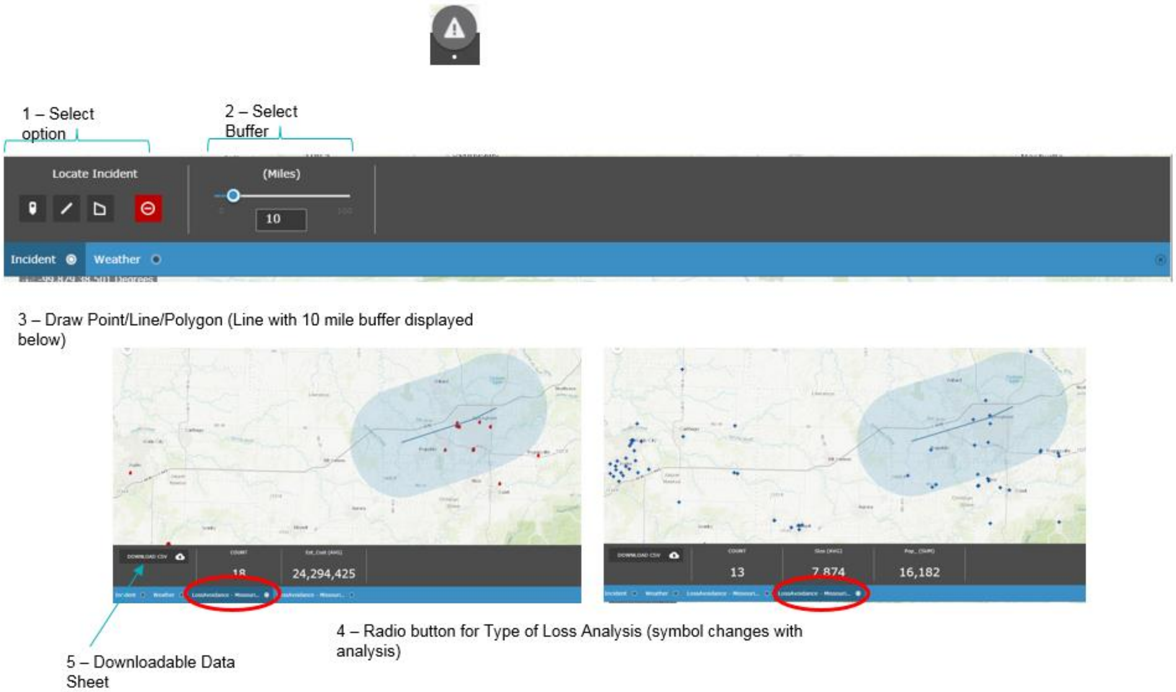
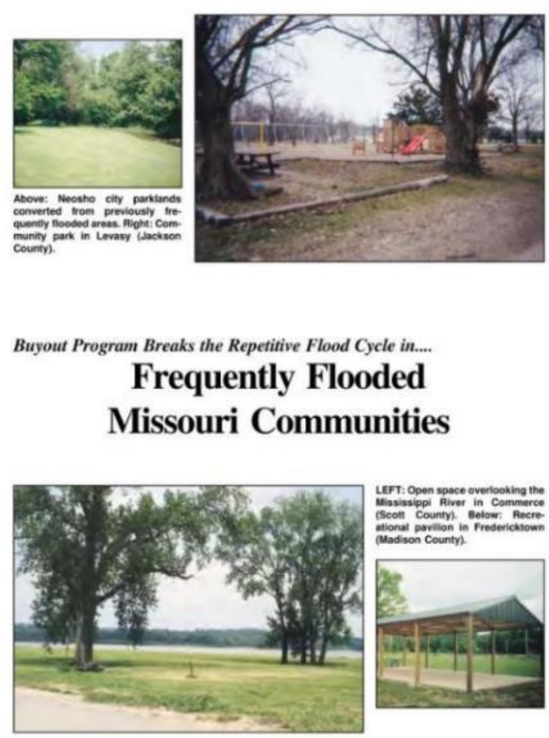


Figure 7.11. LAAT Website – "Incident Analysis" Tool



1999 Loss Avoidance Studies

To demonstrate the success of the buyout programs that occurred after the flooding in 1993, 1994, and 1995, SEMA published the acquisition success story in the 1999 publication *Stemming the Tide of Flood Losses*. This loss avoidance study demonstrated the effectiveness of the buyout program in 22 Missouri communities.



2009 Loss Avoidance Studies

Between 2007 through 2009, there were 13 presidential and emergency disaster declarations issued for Missouri (See **0**).

Table 7.8. Major Disaster and Emergency Declarations in Missouri, 2007-2009

Declaration Date	Disaster No.	Incident Type
June 11, 2007	DR 1708	Severe Storms and Flooding
September 21, 2007	DR 1728	Severe Storms and Flooding
December 12, 2007	EM 3281	Severe Winter Storms
December 27, 2007	DR 1736	Severe Winter Storms
February 5, 2008	DR 1742	Severe Storms, Tornadoes, and Flooding
March 12, 2008	DR 1748	Severe Winter Storms and Flooding
March 19, 2008	DR 1749	Severe Storms and Flooding
May 23, 2008	DR 1760	Severe Storms and Tornadoes
June 25, 2008	DR 1773	Severe Storms and Flooding
November 12, 2008	DR 1809	Severe Storms, Flooding, and a Tornado
January 30, 2009	EM 3303	Severe Winter Storms
February 17, 2009	DR 1822	Severe Winter Storms
June 19, 2009	DR 1847	Severe Storms, Tornadoes, and Flooding

Source: Federal Emergency Management Agency

Following the spring and summer floods of 2008 (DR-1749 and DR-1773), FEMA partnered with the State of Missouri to complete a Loss Avoidance Study to assess the effectiveness of the acquisition/demolition projects in eastern Missouri along the Mississippi River and its tributaries. The report "*Loss Avoidance Study: Eastern Missouri, Building Acquisition Part One: General Overview and Part Two: Detailed Methodology*" provides detailed documentation of the methodology implemented and results.

For this study, FEMA employed the loss avoidance methodology, as previously described:

1) **Initial Project Selection** – The initial project list covered eight counties, nine communities, 20 residential acquisition projects, and 2,049 properties. The properties included 1,091 residential buildings and 958 vacant lots. The communities were located in eastern Missouri and include the Cities of Arnold, La Grange, Cape Girardeau, St. Charles, Hannibal, Winfield, Piedmont, Marble Hill, and the County of St. Charles. Data collection efforts for the projects resulted in the elimination of several buildings from the study due to the lack of flood impact from the 2008 storm events, the lack of available structure location data, and incomplete acquisition/demolition activities. A total of 885 buildings proceeded to Phase 2 of the loss avoidance study. The vacant lots, which were acquired to create continuous open space areas, were not analyzed in Phase 2, but were included in the final return on investment computations as a project cost.

2) **Project Effectiveness Analysis** – For this loss avoidance study, a flood inundation analysis was conducted. The flood depth that would have occurred inside each building, had the building not been acquired, was calculated. Flood depths were calculated using both stream gage stage data and discharge data.

   Cross sections from the Flood Insurance Studies (FIS) for the project area were digitized in a GIS environment. Stream gage stage data was input at the cross section corresponding to the gage location, and it was noted which recurrence intervals the stage fell between using the FIS or USACE flood profiles. Water surface elevations (WSEs) at the remaining cross sections along the stream

profile were then interpolated through hand calculations using the appropriate recurrence intervals as lower and upper bounds. The water surface elevations were input into GIS and converted to a water surface layer.

Where stream gage data was not available, discharge data was used. The lower and upper bounding recurrence intervals were determined from the discharge tables within the FIS reports. The elevation corresponding to the recurrence interval was found on the FIS flood profile for each cross section, and a water surface layer was created.

Once flood surfaces were digitally created for the 2008 storm events affecting the communities, the flood depth at each building location (measured from the WSE to the ground) was extracted and exported in table format. Ground-surface elevations were derived from USGS digital elevation models (DEMs). The flood depth *inside* each building was then determined by adjusting the flood depth based on the first-floor elevation.

3) **Loss Estimation Analysis** – As previously noted, all buildings included in the study are residential structures. Therefore, the loss estimation analysis included physical damage (building and contents) and loss of function (displacement expense and disruption of residents). Loss of business income, lost wages, and loss of public service damages were not calculated.

Physical damages to the buildings and contents were based upon the flood depths determined in Phase 2 and computed using FEMA's Benefit Cost Analysis (BCA) Version 4 software, the U.S. Army Corps of Engineer's generic building damage curves, and the Federal Insurance Administration mobile home damage curves.

Displacement cost was estimated based upon the repair time and utilized default values for one-time displacement and monthly rental costs. For disruption, FEMA BCA Version 4 software guidance provides a national average wage. The time of disruption was calculated using the estimate that each adult occupant is disrupted 40 hours plus 8 hours for every 1% of building damage.

The losses avoided for the spring and summer 2008 events were calculated for each individual building. The cumulative amount of losses avoided was then calculated for both the Mitigation Project Absent (MPA) and Mitigation Project Complete (MPC) scenarios. The total losses in the MPC scenario were then subtracted from the total losses in the MPA scenario to determine the total losses avoided. It should be noted, no losses were calculated for the MPC scenario because the buildings no longer existed and thus no damages could be incurred. The total losses avoided for the communities were valued at $93.6 million.

Calculating the return on investment (ROI) is the final task of Phase 3. The ROI is calculated by dividing the losses avoided by the total investment for the project made by all parties involved. For this study, the project cost was valued at $44.2 million, resulting in a return on investment of 212-percent. **Table 7.9** presents the lost estimation results.

Table 7.9. Eastern Missouri Loss Avoidance Study Results

AGGREGATE RETURN ON MITIGATION INVESTMENT										
Analysis Information			Results by Loss Category							
Community	Disaster, Project Number, and Event	Number of Buildings Included in Analysis	Building Damage	Contents Damage	Displacement Cost	Disruption Cost	Total Losses Avoided	Project Investment	Project ROI	Community ROI
Arnold	995-0002 (spring)	79	$3,175,228	$2,876,203	$724,396	$880,433	$8,010,297	$7,054,582	85%	77%
	FMA-PJ-07MO-1997002 (spring)	1	$48,198	$26,934	$6,910	$12,205	$94,246	$104,435	90%	
	FMA-PJ-07MO-1998002 (spring)	3	$48,890	$29,378	$2,411	$15,752	$96,430	$328,901	29%	
	FMA-PJ-07MO-1999001 (spring)	6	$25,506	$18,603	$0	$10,171	$54,280	$675,885	8%	
La Grange	995-0027 (summer)	11	$481,105	$296,842	$124,431	$447,650	$1,265,024	$243,811	519%	519%
Cape Girardeau	1054-0001 (spring)	79	$380,568	$238,370	$34,488	$190,280	$843,706	$2,803,431	30%	49%
	1054-0001 (summer)	79	$871,664	$547,830	$131,176	$453,816	$1,830,644	$2,803,431	69%	
	1403-0004 (spring)	2	$0	$0	$0	$0	$0	$60,629	0%	
	1403-0004 (summer)	2	$1,036	$884	$0	$2,832	$4,863	$60,629	8%	
St. Charles County	995-0001 (summer)	467	$27,889,023	$18,899,004	$6,028,505	$8,911,969	$55,752,634	$22,572,245	247%	247%
City of St. Charles	995-0027 (summer)	9	$0	$0	$0	$0	$0	$423,247	0%	
Hannibal	995-0004 (summer)	90	$6,704,530	$5,898,533	$1,677,624	$2,224,599	$13,314,236	$2,220,253	600%	600%
Winfield	995-0015 (summer)	49	$2,984,398	$2,349,148	$636,307	$1,336,120	$6,215,974	$1,387,803	448%	448%
Piedmont	995-0045 (spring)	15	$796,451	$608,444	$175,855	$600,524	$1,886,888	$387,547	487%	304%
	1006-0007 (spring)	19	$791,188	$577,325	$191,006	$487,771	$1,817,425	$724,121	251%	
	1023-0005 (spring)	2	$190,473	$155,464	$42,612	$64,007	$371,325	$47,708	778%	
	1054-0008 (spring)	10	$474,636	$356,478	$107,885	$245,035	$1,039,470	$446,518	233%	
	1403-0008 (spring)	10	$195,866	$113,477	$33,684	$138,653	$481,680	$480,375	98%	
	FMA-PJ-07MO-1997003 (spring)	10	$834,854	$738,287	$185,758	$420,962	$1,740,581	$365,773	476%	
	FMA-PJ-07MO-1998003 (spring)	6	$320,542	$286,888	$74,559	$193,162	$718,302	$189,425	378%	
Marble Hill	1403-0011 (spring)	28	$0	$0	$0	$0	$0	$762,707	0%	0%
		TOTAL	$45,974,342	$34,999,281	$10,179,708	$16,638,259	$93,638,111	$44,153,436		212%

Source: FEMA Loss Avoidance Study: Eastern Missouri, Building Acquisition Part Two: Detailed Methodology, page 5-19.

SEMA continues to provide success stories to FEMA and to organizations like the Association of State Floodplain Managers to educate the public about the effectiveness of mitigation.

2017 Loss Avoidance Study

On May 9, 2011 the Federal Emergency Management Agency (FEMA) announced that federal disaster aid would be made available to Missouri to supplement assistance from state and local governments in areas struck by severe storms, tornadoes, and straight-line winds and associated flooding during the period of April 19, 2011 through May 11, 2011. This disaster declaration was designated as DR-1980 and provided federal funding for Hazard Mitigation Grant Programs (HMGP) that were administered by the Missouri State Emergency Management Agency (SEMA).

After this event the state prioritized a program to acquire and remove properties that were subject to repetitive flooding utilizing the HMGP program. As a part of DR-1980 the state acquired and demolished approximately 40 properties with the resulting land dedicated to open space in perpetuity. This Loss Avoidance Study (LAS) looked at the acquisition projects that were implemented by cities, villages and one county in this HMGP. Those projects included: Taney County, City of Branson, Village of Dutchtown, and City of Doniphan.

The Flood Acquisition Loss Avoidance Calculator developed for FEMA was utilized to determine the avoided costs for the properties in these projects. This model assumes that the structure would have remained and would have been flooded in subsequent events. Determining the flood elevation for subsequent flood events turned out to be critical in assessing future losses and was the most difficult data point to acquire. In some cases, a site visit was necessary to acquire high water marks and in some cases the necessary data could be acquired from the agency that administers the National Flood Insurance Program (NFJP) for that jurisdiction. If sufficient data was not available to estimate future losses, those properties were excluded from the study.

The result of this study showed the following for the buyout projects:

Table 7.10. DR-1980 Loss Avoidance Study Results

Acquiring Agency	Structure Cost (present value)	Avoided Losses		Total Avoided Losses	Loss Avoidance Ratio L_R		
		2015 (DR 4250)	2017 (DR 4317)		After 2015 Flood	After 2017 Flood	Total
Taney County	$1,289,154	$1,321,699	$1,164,712	$2,486,411	1.03	0.90	1.93
City of Branson	$694,991	$459,854	$336,592	$796,446	0.66	0.48	1.15
Village of Dutchtown	$1,133,285	$2,012,408	$826,849	$2,839,257	1.78	0.73	2.51
City of Doniphan	$194,754	$0	$782,335	$782,335	0.00	4.02	4.02
Total	**$3,312,184**	**$3,793,961**	**$3,110,488**	**$6,904,449**	**1.15**	**0.94**	**2.08**

Source: FEMA Loss Avoidance Study: DR-1980 Missouri Acquisition Projects, Executive Summary Table calculations corrected for inclusion in 2018 State Plan Update.

This indicates that the Loss Avoidance Ratio (L_R), utilizing the FEMA calculator was greater than one for these projects, following the two flood events, and therefore provided the state of Missouri with significant cost savings through avoided losses in subsequent flood events.

2018 Loss Avoidance Studies

For the 2018 State Plan Update, the new loss avoidance analysis tool (LAAT) was utilized to calculate the losses avoided for residential acquisition projects in 12 counties with recent disaster declarations DR-4250 and DR-4317. This coarse computation assumed the acquired and demolished residential structures formerly located within the 1-percent annual chance floodplain would have remained and would have been substantially damaged in the disaster declaration events.

A refined loss avoidance example computation for Taney County, as well as step-by-step instructions for the LAAT, are presented in **Appendix E**.

Figure 7.12. Counties Impacted by DR-4250 and DR-4317

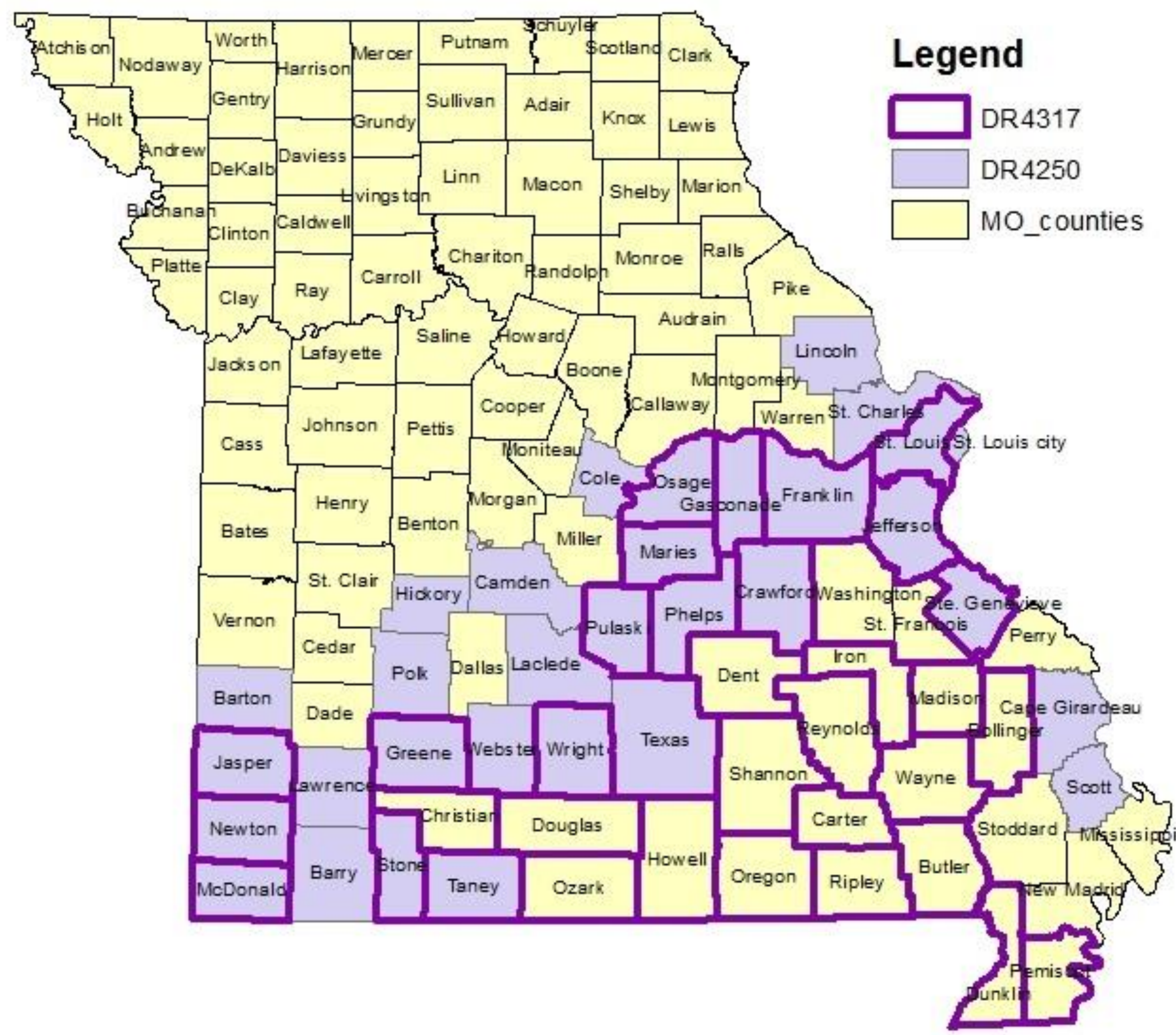


Table 7.11. Loss Avoidance Results for All Missouri Buyouts, DR-4250 and DR-4317

Community	Total # of Acquired Structures	Total # of Acquired Structures Located within the SFHA	Total Project Investment	Avoided Loss DR 4250		Avoided Loss DR 4317		Total Avoided Loss	Loss Ratio DR 4250	Loss Ratio DR 4317	Total Loss Ratio
				Structure Damage	Contents Damage	Structure Damage	Contents Damage				
Franklin	156	101	$4,103,010	$4,321,697	$2,160,849	$4,321,697	$2,160,849	$12,965,091	1.58	1.58	**3.16**
Gasconade	6	2	$556,074	$48,354	$24,177	$48,354	$24,177	$145,062	0.13	0.13	**0.26**
Greene	18	9	$1,128,880	$431,477	$215,739	$431,477	$215,739	$1,294,431	0.57	0.57	**1.15**
Jasper	3	2	$126,341	$84,228	$42,114	$84,228	$42,114	$252,684	1.00	1.00	**2.00**
Jefferson	517	147	$9,338,333	$3,080,801	$1,540,401	$3,080,801	$1,540,401	$9,242,403	0.49	0.49	**0.99**
Montgomery	77	4	$328,281	$96,708	$48,354	$96,708	$48,354	$290,124	0.44	0.44	**0.88**
Newton	68	53	$1,791,146	$1,375,476	$687,738	$1,375,476	$687,738	$4,126,428	1.15	1.15	**2.30**
Pulaski	19	8	$505,225	$212,728	$106,364	$212,728	$106,364	$638,184	0.63	0.63	**1.26**
St. Charles	1456	570	$15,459,051	$12,614,507	$6,307,254	$10,352	$5,176	$18,937,289	1.22	0.00	**1.22**
St. Louis	676	402.5	$19,598,189	$16,348,990	$8,174,495	$16,322,430	$8,161,215	$49,007,130	1.25	1.25	**2.50**
Ste. Genevieve	81	33	$1,038,091	$390,012	$195,006	$390,012	$195,006	$1,170,036	0.56	0.56	**1.13**
Taney	23	21	$3,379,541	$3,376,649	$1,688,325	$3,325,269	$1,662,635	$10,052,877	1.50	1.48	**2.97**
Grand Total	**3100**	**1353**	**$74,073,874**	**$42,381,627**	**$21,190,814**	**$29,699,532**	**$14,849,766**	**$108,121,739**	**0.86**	**0.60**	**1.46**

7.4.3. COVID-19

Missouri received a federal disaster declaration (DR-4490-MO) for the ongoing Covid-19 Pandemic on March 26, 2020. Funding obligations under the declaration included $47.7 million in Individual & Households Program dollars for 7,614 individual assistance applications, $369.6 million in Public Assistance, $20.9M in HMA projects, and $3.5M for management costs. The HMA funding supported hazard mitigation planning. The Public Assistance funding supported 446 Category B emergency work projects as well as state management costs. Project types included testing sites and kits; cleaning, disinfecting, and air quality improvements; staffing support; personal protective equipment; and vaccination operations among others.

Response to the COVID-19 pandemic was an interagency effort, led in large part by the Missouri Department of Health and Senior Services (DHSS), with involvement from the Office of the Governor, the Missouri Department of Elementary and Secondary Education (DESE), and the Missouri National Guard.

DHHS activated incident command in January 2020 and the first positive case was reported in March 2020. Initial responses were locally led; by mid-March, all school districts in Missouri had closed and some local governments issued their own stay-at-home orders. In early April 2020, the Governor issued a statewide stay-at-home order, which was extended to early May 2020, and closed schools for the remainder of the school year. Missouri did not issue any statewide mask requirements or statewide travel restrictions.

DHHS identifies testing capacity, PPE reserves, hospital capacity, and outbreak prediction as the four pillars of recovery from the pandemic. By April 2020, DHSS established a PPE warehouse, created a PPE marketplace, and made a Battelle decontamination system available for health care, and Missouri National Guard began assisting DHHS in holding community testing events. Testing capacity was increased in Missouri through the Missouri State Public Health Laboratory (MSPHL), which provided testing and external partner support, implemented COVID-19 variant sequencing, and onboarded an electronic test ordering and reporting system, improving efficiencies in testing and reporting within MSPHL and the state’s network of laboratories. Over 14 million tests were performed by public health partners in Missouri. At-home test kits supplemented the state’s testing capacity, with free at-home PCR test kits announced in May 2021.

Missouri submitted a vaccine distribution plan to the Centers for Disease Control and Prevention (CDC) in October 2020. The plan identified the organization structure and partner involvement for implementing a vaccination program, established a phased approach to vaccination, identified critical populations, established procedures for provider recruitment and enrollment, discussed vaccine administration capacity, provided a strategy for vaccine allocation, ordering, distribution, and inventory management, and discussed procedures for vaccine storage and handling and vaccine administration documentation and reporting, among other topics. The first vaccine was administered in Missouri in December 2020, and in July 2021 the Missouri Vaccine Incentive Program was implemented.

As of April 1, 2022, Missouri began recognizing COVID-19 as endemic, and DHHS reported stepping down from a pandemic response phase to an endemic surveillance phase, with operations focused on identifying when and where COVID-19 cases are occurring, determining what viruses are variants are circulating, and measuring the severity and impact of COVID-19-associated illnesses.

A May 2020 policy brief from the Center for Health Economics and Policy at Washington University found that social distancing would minimize infections, hospitalizations, and death rates, with

particularly significant impacts in urban areas and areas with vulnerable populations based on age and health.

A September 2021 study from the Milken Institute School of Public Health at George Washington University, *Missouri's Public Health Response to COVID-19: Key Findings and Recommendations for State Action and Investment*, evaluated DHSS and local public health agencies' (LPHAs) response capacity and efficacy and identified the following eight key recommendations for strengthening public health infrastructure in Missouri:

Figure 7.13. Key Recommendations for Strengthening Public Health Infrastructure in Missorui

	Recommendation:	The State of Missouri Should:
1	Provide financial support and technical assistance for public health accreditation.	Create a special fund to provide technical assistance for LPHAs to assess readiness for accreditation via the Public Health Accreditation Board, identify costs to close gaps, and cover fees associated with the accreditation application process.
2	Prioritize equity.	Expand funding, staff, and other supports to help LPHAs integrate equity principles into data collection and reporting and community engagement (i.e., trust building, links to social services). Increase workforce and funding for the Office of Minority Health.
3	Build a modernized surveillance system.	Build a modernized system and provide LPHAs or regional bodies with hardware and software to manage the system, consistent with federal standards.
4	Create regional coordinating bodies.	Incentivize and support greater formal sharing of staffing and services among smaller LPHAs, with a lead public health agency designated to convene and coordinate, designed to develop and strengthen all foundational public health capabilities.
5	Bolster the public health workforce.	Support workforce development through equitable recruiting, hiring, and promotion practices; new training programs; enhanced salaries for LPHA leaders with advanced training; and deploy skilled staff within regions.
6	Ensure equitable public health funding across the state.	Provide a minimum level of funding for LPHAs, linked to delivery of foundational public health services and an equity analysis incorporating social vulnerability, and ensure that public health money flows directly to LPHAs.
7	Clarify LPHA governance structure and authorities.	Commission legal analysis to create greater consistency in decision making and oversight across LPHA governance and financing.
8	Harmonize policy development.	Ensure consistent policies across jurisdictions for public health prevention and mitigation measures. DHSS should establish and adhere to protocols for consultation with LPHAs on new policies during emergencies.

Source: Acosta, Alexis; Benoit, Marie-Anais; Conway, Ciara; Hughes, Dora; Levi, Jeffrey; Markus, Anne; Regenstein, Marsha; Seyoum, Semret; Trott, Jennifer; and Van Bronkhorst, Hope, "Missouri's Public Health Response to COVID-19: Key Findings and Recommendations for State Action and Investment" (2021). Health Policy and Management Issue Briefs. Paper 61.

https://hsrc.himmelfarb.gwu.edu/sphhs_policy_briefs/61

State Estimates of Potential Losses to COVID

For the State Hazard Mitigation Plan Update, pandemic influenza has been used to estimate potential losses from a public health emergency. With the recent COVID-19 pandemic, a comparison between the estimated potential losses and known COVID cases has been performed.

Number of Cases

- For a public health emergency, an assumption of 30 percent of the general population was used to estimate the population that could become ill with influenza. The Missouri Department of Health and Senior Service's Pandemic Influenza Response Plan utilizes this estimate for planning purposes.
- For the COVID-19 pandemic, the number of actual cases for each Missouri County was obtained from USA Facts which aggregated data from the Centers for Disease Control and Prevention (CDC), and state- and local-level public health agencies. County-level data was confirmed by referencing state and local agencies directly.
  (Source: Detailed Methodology and Sources: COVID-19 Data - USAFacts)

Age Distribution

- For a public health emergency, the distribution of cases by age was obtained from a published research study "*The Economic Impact of Pandemic Influenza in the United States: Priorities for Intervention*", M I Meltzer, N J Cox, and K Fukuda
  (Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2627723/)
  - For a public health emergency, the default values for the percentage of high risk cases from CDC's FluAid were utilized. FluAid is a software created by the CDC to assist state and local level planners in preparing for next influenza pandemics by providing estimates of potential impact specific to their locality.
    (Source: https://www.cdc.gov/flu/pandemic-resources/tools/downloads/pandemic-impact-estimate-instructions.pdf)
- For the COVID-19 pandemic, the distribution of cases by age was obtained from the Centers for Disease Control.
  (Source: CDC COVID Data Tracker: Total Cases and Deaths by Race/Ethnicity, Age, and Sex)
  - For the COVID-19 pandemic, the CDC reports that older people and younger adults with serious medical conditions, such as heart disease, diabetes, lung disease, asthma and obesity have a greater risk of becoming severely ill if infected with COVID-19. Percentage of adults 18 and older at higher risk of serious illness for Missouri were determined to be 40.5% (18-64yrs) and 53.8 (over 65 yrs).
    (Source: https://www.kff.org/coronavirus-covid-19/issue-brief/how-many-adults-are-at-risk-of-serious-illness-if-infected-with-coronavirus/)
  - Data for high risk cases and hospitalizations of high risk cases was not available for the 0-17 year age group for COVID-19.
- The same rate of hospitalizations for high risk cases was utilized for both influenza pandemic and COVID-19 pandemic.

Cost

- For a public health emergency, the estimated direct and indirect health care costs were obtained from a published research study "*The Economic Impact of Pandemic Influenza in the United States: Priorities for Intervention*" and inflated for current date (December 2021).

- For the COVID-19 pandemic, the estimated direct and indirect health care costs were obtained from Fair Health. FAIR Health is an independent nonprofit that collects data for and manages the nation's largest database of privately billed health insurance claims and is entrusted with Medicare Parts A, B and D claims data for 2013 to the present. **Figure 7.14** presents cost information for the State of Missouri.
  (Source: [States by the Numbers: COVID-19 Cost Tracker | FAIR Health])

Figure 7.14. COVID-10 Medical and Hospitalization Costs for Missouri

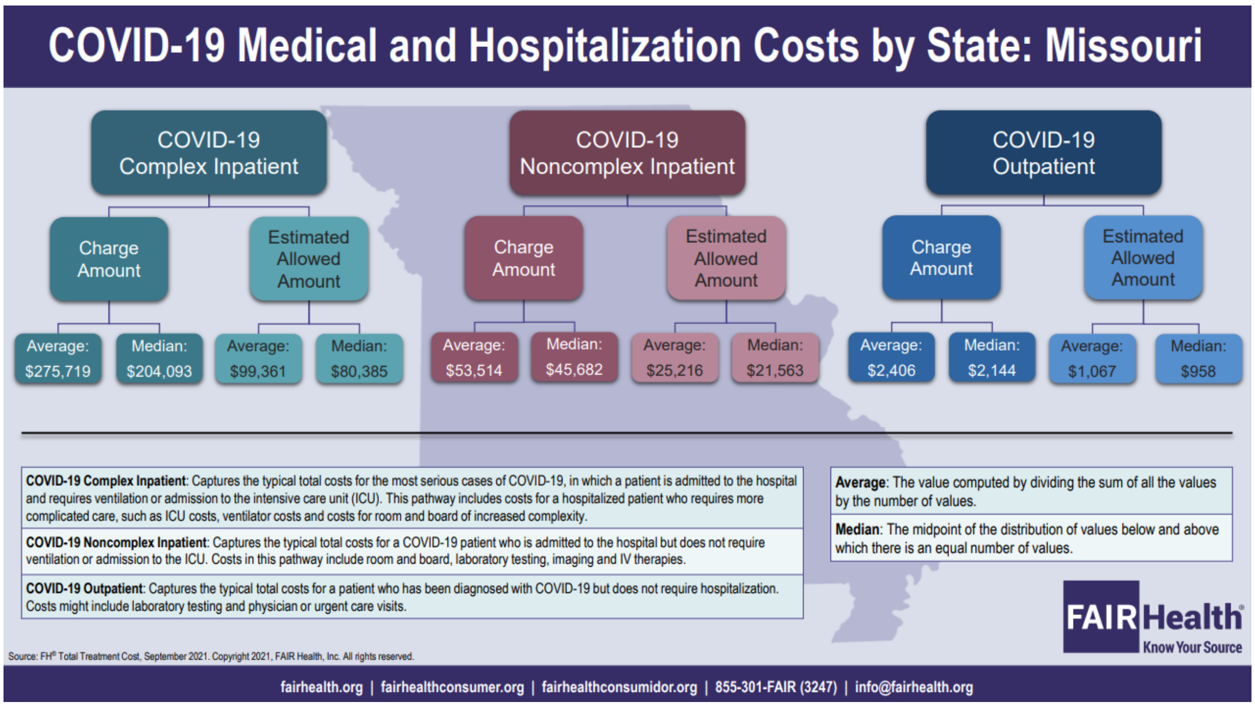


Table 7.12 below presents the estimates for age distribution and disease outcome for both the influenza pandemic and the COVID-19 pandemic.

Table 7.12. Estimate of Age Distribution of Cases and Percentage of Hospitalizations

<u>INFLUENZA PANDEMIC ESTIMATES</u>

Age Group	Age Distribution of Cases		Distribution of Disease Outcomes for 1918-type Pandemic Rates per 1,000 Persons		Economic Impact
	Percentage of All Cases	Percentage of High Risk Cases	Hospitalizations NOT at High Risk	Hospitalizations AT High Risk	Hospitalization Costs (in 2021 US$)
0-19	40.0	6.4	4.110	23.838	$5,333
20-64	53.1	14.4	12.042	24.578	$10,927
65+	6.8	40.0	18.495	69.871	$12,453

COVID-19 PANDEMIC ESTIMATES

Age Group	Age Distribution of Cases		Distribution of Disease Outcomes for 1918-type Pandemic Rates per 1,000 Persons		Economic Impact
	Percentage of All Cases	Percentage of High Risk Cases	Hospitalizations NOT at High Risk	Hospitalizations AT High Risk	Hospitalization Costs (in 2021 US$)
0-17	18.0	N/A	N/A	N/A	$1,067
18-64	70.0	40.5%	12.042	24.578	$25,216 (not high risk) $99,361 (high risk)
65+	12.0	53.8%	18.495	69.871	$25,216 (not high risk) $99,361 (high risk)

Source: [1]The Economic Impact of Pandemic Influenza in the United States: Priorities for Intervention; Martin I. Meltzer, Nancy J. Cox, and Keiji Fukuda; https://www.ncbi.nlm.nih.gov/pubmed/10511522; and
[2]CDC Flu Surge Model; https://www.cdc.gov/flu/pandemic-resources/tools/downloads/pandemic-impact-estimate-instructions.pdf

In general, the distribution of cases by age group for COVID-19 is heavier for adults and seniors over 65 years; the distribution of high risk cases is also greater for adults and seniors over 65 with COVID-19 than influenza pandemic; and the cost of outpatient and inpatient care is significantly greater than the estimates for influenza pandemic.

As a result, of the updated loss calculations the top ten counties for potential loss estimates are presented in the following table. As the calculations rely heavily on population, the top ten counties are the same although ranking varies due to senior population within the counties. In comparison to the influenza pandemic, the loss estimations identify the population centers to focus upon, but the scale of the pandemic was significantly underestimated. All county data is presented in **Appendix A**.

Table 7.13. Comparison of Loss Estimates for Top-Ten Counties for Influenza Pandemic and COVID-19 Pandemic

Influenza Pandemic			COVID-19 Pandemic		
County		Total Economic Impact	County	Total Economic Impact	Difference
St. Louis		$37,317,640	St. Louis	$320,654,658	$283,337,018.31
Jackson		$26,250,003	Jackson	$310,013,687	$283,763,684.10
St. Charles		$14,927,071	St. Charles	$139,306,734	$124,379,662.89
St. Louis, City		$11,414,636	Greene	$103,907,612	$92,492,975.81
Greene		$10,922,589	St. Louis, City	$83,532,959	$72,610,370.15
Clay		$9,233,332	Jefferson	$80,171,089	$70,937,756.73
Jefferson		$8,420,321	Boone	$64,371,489	$55,951,168.27
Boone		$6,731,852	Jasper	$51,373,943	$44,642,091.25
Jasper		$4,515,073	Clay	$40,073,665	$35,558,592.59

7.5. Effective Use of Available Mitigation Funding

Requirement §201.5(b)(3): The enhanced plan must demonstrate that the state effectively uses existing mitigation programs to achieve its mitigation goals.

This section identifies some general and specific hazard mitigation projects. They are examples of the types of projects that have made, and continue to make, Missouri's hazard mitigation program effective and successful. These projects, and others like them, have been approved in the past based on their ability to achieve some, or all, of the State's mitigation goals and objectives. Because of this demonstrated success, similar projects are likely to be approved in the future.

As a result of the successes achieved through past and present mitigation funding sources and through public-private partnerships, SEMA remains committed to continuing its efforts to encourage leveraging available funds and establishing partnerships for project leadership, implementation, and maintenance. The following table (**Table 7.14**) reiterates the effectiveness of actions funded through SEMA and how they relate to the State's mitigation goals and the Emergency Management Accreditation Program's (EMAP) mitigation standards.

Table 7.14. Missouri Mitigation Action Categories Strategy Overview

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action
M1—State and Local Hazard Mitigation Plans	High	SEMA/RPCs/ local jurisdictions	All	Continued use of RPCs	Life Safety and Property
M2—NFIP Floodplain Management and Community Rating System	High	SEMA/local jurisdictions	Flood	Community assistance visits, workshops	Life Safety and Property
M3—Risk Communication	High	SEMA and other agencies	All	Vulnerability assessment data provided for local plans	Life Safety and Property
M4—Voluntary Property Acquisitions (Flood Buyout)	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Life Safety and Property
M5—Voluntary Elevation, Relocation, Floodproofing	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Life Safety and Property
M6—Tornado Safe rooms	High	SEMA/local jurisdictions	Tornado	Projects identified in local plans	Life Safety
M7—Earthquake/High Wind Structural Mitigation Projects	Medium	SEMA/MoDOT	Earthquake Tornado	Projects identified in local plans	Life Safety

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action
M8—Earthquake/High Wind Nonstructural Mitigation Projects	Medium	SEMA/local jurisdictions	Earthquake Tornado	Projects identified in local plans	Life Safety and Property
M9—Structural/ Infrastructure Mitigation Projects (including Public Assistance projects)	Medium	SEMA/MoDOT/ local jurisdictions	Multiple	Projects identified in local plans	Life Safety and Property
M10—Response and Recovery Facility Mitigation Projects	Medium	SEMA and other agencies	Multiple	Vulnerability assessment data provided for local plans	Life Safety and Property
M11—State Owned/Operated Facility Mitigation Projects	Medium	SEMA and other agencies	Multiple	Vulnerability assessment data provided for local plans	Life Safety and Property
M12—Buried Electric Service Lines	Low	Local jurisdictions/ certain utility providers	Multiple	Projects identified in local plans	Life Safety and Property
M13—State 5% Initiative Projects	Low	SEMA/local jurisdictions	Multiple	Projects identified in local plans, difficult to measure cost-effectiveness	Life Safety and Property
M14—Technical Assistance	Low	SEMA and other agencies	Multiple	Needs identified in local plan capability assessments	Life Safety and Property

Table 7.15. Mitigation Action Categories and Goals Crosswalk

Objectives	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
	Goal 1: Improve the Protection of Human Life, Health, and Safety													
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Goal 2: Improve the Protection of Continuity of Government and Essential Services													
Objective 1	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
	Goal 3: Improve the Protection of Public and Private Property													
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Goal 4: Improve the Protection of Community Tranquility													
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 7.16 provides specific types and numbers of projects and funding amounts from 2002-2022. For reference, the corresponding Mitigation Action Category is also provided. For additional details on funding by year, see **Section 4.2**.

Note, mitigation action categories M3 Risk Communication, M10 Response and Recovery Facility Mitigation Projects, and M11 State Owned/Operated Facility Mitigation Projects were added with the 2018 plan update and therefore do not have prior associated projects.

Table 7.16. Summary of Mitigation Actions Implemented and Estimated Funding Amounts, 2002–2012, 2013-2017, and 2018-2022

Project Type	Action Category	2002-2012 Number of Projects	2002-2012 Estimated Funding Amount	2013-2017 Number of Projects	2013-2017 Estimated Funding Amount	2018-2022 Number of Projects	2018-2022 Estimated Funding Amount
State and Local Hazard Mitigation Plans[1]	M1	258	$7,885,551	5	$1,096,856	6	$2,691,742
Warning Systems	M3	---		---		21	$682,193
Flood Buyouts	M4	67	$47,337,218	18	$8,458,688	30	$9,838,131
Flood Elevations	M5	3	$488,573	---		---	
Tornado Safe Rooms	M6	133	$159,925,978	62	$68,575,060	44	$57,832,150
Tornado Safe Rooms - Multipurpose	M6	1	$686,493	---		---	
Bridge Replacements	M9	1	$449,787	---		---	
Low Water Crossings	M9	8	$888,246	2	$432,896	---	
Streambank Stabilizations	M9	2	$92,267	---		---	
Basin	M9	1	$1,333,333	---		---	
Culvert	M9	2	$553,625	---		---	
Water Supply Interconnects	M9	1	$66,701	---		---	
Utility Protective Measures	M9	---		---		2	$968,946
Infrastructure Protective Measures	M9	---		---		4	$1,760,546
Generators	M10	---		---		6	$517,678
Buried Electric Lines	M12	10	$11,959,530	---		---	
State 5% Initiative Projects	M13	12	$1,753,866	10	$598,378	---	

[1]Note: This table reflects the number of grants, not the total number of plans completed. Multiple plans were completed through some grant projects; therefore the total number of plans completed is much higher.

This provides documentation of the State's ability to make use of funding available from FEMA HMA grant programs to implement the State's mitigation strategy. There have been instances in the past when the total amount for HMA grants could not be fully obligated. In all instances, the State forwarded applications and supplements to exhaust all available funding options. However, due to circumstances beyond the State's control, such as project cost underruns, loss of local match, local withdrawal of projects, or decrease in scope due to the voluntary nature of some projects, funds could not be fully obligated. In these instances, the availability of funds was not known until after the application periods had expired. Therefore, the State was not at liberty to forward additional applications to make use of any remaining funds. With the 2018 State Plan Update, a new mitigation action was added to pursue mitigation of state owned/operated facilities which have been identified through the refined risk assessments as at risk. As this mitigation action is implemented in the coming years, SEMA may seek to identify potential mitigation projects, such as strapping/bracing or other non-structural measures for those state owned/operated facilities identified within the high shake zones. With small projects identified early, SEMA could potentially be poised to utilize all available funding. This ongoing mitigation

action did not gain much traction during the years of the pandemic but is still an active and viable strategy for the future.

The following activities illustrate the types of projects that have been approved as part of the State's mitigation program. This list is not all-inclusive; however, it does demonstrate the effective use of available mitigation funding and how SEMA has used FEMA and non-FEMA funding to support mitigation in Missouri.

Local Hazard Mitigation Plan Development (M1)

As of September 2022, there were 107 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives.

Mitigation funds have been used to help communities throughout the State develop hazard mitigation plans. As part of this process, these communities have developed public-private partnerships that have expanded their work into other mitigation-related activities. As a result of planning activities, communities are now more aware of the benefits of an active mitigation program and have instituted mitigation projects with their own funds.

The local mitigation planning project supports all of the goals of this plan by contributing to the development of local plans that complement the State plan and serving as the foundation for FEMA HMA grant eligibility (see **Table 7.15** and **Table 7.16**). Historically, local hazard mitigation plans in Missouri have been funded through the Hazard Mitigation Grant Program and the Pre-Disaster Mitigation program with local matching funds and/or in-kind services.

Preparation/Updating of Floodplain Maps (M2 and M14)

Funds from a variety of programs have been used to develop flood maps for previously unmapped areas and to revise/update older existing maps. This initiative will enable more communities in the State to join the National Flood Insurance Program (NFIP). As a result, more individuals, families, and businesses will be able to get insurance to cover future flood-related losses.

The Paper Inventory Reduction (PIR) program will assist in getting paper-only floodplain maps updated to a digital format. There were 33 PIR counties in Missouri. All 33 have been funded for countywide updates and all 33 now have digital models available. Nine of the counties are now *effective*. Additionally, all 33 PIR counties have 2D models funded. SEMA is coordinating with these counties throughout the Risk MAP process and encouraging participation in the NFIP, as well as the CRS program. Handouts covering the process to join the NFIP have been developed by SEMA to assist non-participating communities. The current status of the Risk MAP program across the state is provided in the flooding hazard discussion in **Section 3.3.1**.

SEMA was among the first states in the nation to fully commit in2018 to FEMA's goal of two-dimensional (2D) modeling for all streams in the National Flood Insurance Program (NFIP) as a standard practice. Utilizing the 5-Year funding plan, all 114 counties plus the City of St. Louis are assured to have updated mapping with needed new 2D modeling using the newest topography available. As of May 2023, SEMA is on schedule to have 2D models available and/or funded statewide by 2027.

The Missouri Risk MAP effort supports all of the goals and objectives of this plan as indicated in **Table 7.15** and **Table 7.16**. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies are used to leverage funding. In Missouri, three cities, three counties, and SEMA participate in FEMA's Cooperating Technical Partners (CTP) Program. CTP partnerships are established with NFIP participants

that have both the interest and capability to become more active in the FEMA flood hazard mapping program by collaborating to maintain up-to-date flood hazard maps and other flood hazard information.

Acquisition of Primary Residences in Flood-Prone Areas (M4 & M5)

The State has previously, and most likely will continue to, make the acquisition of primary residences in flood-prone areas a top priority. Hazard Mitigation Grant Program funds from previous Missouri disasters have been used to fund this extremely successful program. The Missouri Community Buyout Program was recognized as a model for the nation following the devastating 1993 floods.

This program removed families and insurable buildings from harm's way. By doing so, it eliminated the threat of flooding and the associated financial and emotional hardship on those families that participated in the program; reduced the cost of future disasters to the federal, state, and local government; and provided the participating community with open space to develop parks for the entire community to enjoy. It also has reduced impacts on local first responders, who have fewer life safety emergencies to handle during floods.

Since the 1993 flood, this buyout program has continued to demonstrate how Missouri has effectively used available mitigation funding programs and packaged these mitigation funds with funds from non-FEMA sources. FEMA funds have been matched, as appropriate, with Community Development Block Grants (including supplemental appropriations for Unmet Needs), State general revenue, and local government funds.

Through the Silver Jackets program, SEMA has proposed, and was awarded funding in late 2017, to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy will identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy will rank the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state. To date, 30 projects have been funded through this initiative.

The buyout program supports the goals and objectives of this plan as indicated in **Table 7.15** and **Table 7.16**. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies can be used to leverage funding.

Acquisition of Severe Repetitive Loss (SRL) Properties (M4)

Over the history of the SRL property acquisition program, the State of Missouri has mitigated 509 SRL properties with total paid NFIP claims of over $64 million in 28 counties. In St. Charles and St. Louis Counties, more than 100 SRL properties have been mitigated in each. **Table 7.17** below shows the number of mitigated SRL properties by community.

Table 7.17. Mitigated Severe Repetitive Loss Properties by County

County/Community	Count of Mitigated	Sum of Total Losses	Sum of Total Paid	Sum of Average Paid
ANDREW COUNTY	**1**	**3**	**$81,906**	**$27,302**
ANDREW COUNTY*	1	3	$81,906	$27,302
BUTLER COUNTY	**1**	**4**	**$83,777**	**$20,944**
BUTLER COUNTY*	1	4	$83,777	$20,944
CALLAWAY COUNTY	**1**	**9**	**$56,016**	**$6,224**
MOKANE, CITY OF	1	9	$56,016	$6,224
CAPE GIRARDEAU COUNTY	**8**	**40**	**$504,151**	**$96,123**
CAPE GIRARDEAU, CITY OF	8	40	$504,151	$96,123
CHRISTIAN COUNTY	**1**	**7**	**$121,668**	**$17,381**
OZARK, CITY OF	1	7	$121,668	$17,381
CLAY COUNTY	**1**	**7**	**$101,581**	**$14,512**
MOSBY, CITY OF	1	7	$101,581	$14,512
COLE COUNTY	**1**	**8**	**$111,652**	**$13,956**
JEFFERSON CITY, CITY OF	1	8	$111,652	$13,956
FRANKLIN COUNTY	**3**	**8**	**$331,370**	**$130,352**
EUREKA, CITY OF	1	4	$141,331	$35,333
PACIFIC, CITY OF	2	4	$190,039	$95,019
GASCONADE COUNTY	**1**	**2**	**$27,420**	**$13,710**
HERMANN, CITY OF	1	2	$27,420	$13,710
GREENE COUNTY	**1**	**3**	**$281,084**	**$93,695**
GREENE COUNTY *	1	3	$281,084	$93,695
HOLT COUNTY	**28**	**103**	**$4,491,171**	**$1,251,639**
BIG LAKE, VILLAGE OF	26	95	$4,192,635	$1,177,005
HOLT COUNTY*	2	8	$298,536	$74,634
JACKSON COUNTY	**3**	**16**	**$1,124,843**	**$221,189**
KANSAS CITY, CITY OF	3	16	$1,124,843	$221,189
JEFFERSON COUNTY	**52**	**339**	**$6,722,003**	**$1,032,038**
ARNOLD, CITY OF	18	114	$2,297,763	$391,765
CRYSTAL CITY, CITY OF	5	29	$404,899	$73,232
JEFFERSON COUNTY*	27	185	$3,788,560	$523,901
PEVELY, CITY OF	1	6	$90,501	$15,084
SCOTSDALE, VILLAGE OF	1	5	$140,279	$28,056
LINCOLN COUNTY	**16**	**89**	**$1,610,594**	**$286,320**
CHAIN OF ROCKS, VILLAGE OF	1	6	$219,956	$36,659
FOLEY, CITY OF	1	4	$62,240	$15,560
LINCOLN COUNTY *	12	69	$1,219,631	$200,024
WINFIELD, CITY OF	2	10	$108,767	$34,077

County/Community	Count of Mitigated	Sum of Total Losses	Sum of Total Paid	Sum of Average Paid
MARIES COUNTY	**1**	**4**	**$69,315**	**$17,329**
MARIES COUNTY*	1	4	$69,315	$17,329
OSAGE COUNTY	**1**	**2**	**$45,717**	**$22,858**
OSAGE COUNTY*	1	2	$45,717	$22,858
PEMISCOT COUNTY	**1**	**4**	**$98,238**	**$24,560**
CARUTHERSVILLE, CITY OF	1	4	$98,238	$24,560
PHELPS COUNTY	**2**	**7**	**$520,256**	**$144,265**
PHELPS COUNTY*	2	7	$520,256	$144,265
PIKE COUNTY	**2**	**28**	**$258,816**	**$19,094**
PIKE COUNTY *	2	28	$258,816	$19,094
PLATTE COUNTY	**1**	**9**	**$361,060**	**$40,118**
PLATTE COUNTY*	1	9	$361,060	$40,118
PULASKI COUNTY	**1**	**4**	**$99,014**	**$24,753**
WAYNESVILLE, CITY OF	1	4	$99,014	$24,753
SCOTT COUNTY	**1**	**6**	**$67,769**	**$11,295**
COMMERCE, CITY OF	1	6	$67,769	$11,295
ST. CHARLES COUNTY	**223**	**1,650**	**$25,714,637**	**$3,583,352**
PORTAGE DES SIOUX, CITY OF	10	65	$1,028,882	$160,973
ST. CHARLES COUNTY *	203	1,491	$23,282,300	$3,267,845
ST. CHARLES, CITY OF	4	36	$424,268	$49,180
ST. PETERS, CITY OF	1	14	$248,549	$17,754
WEST ALTON, TOWN OF	5	44	$730,638	$87,600
ST. FRANCOIS COUNTY	**1**	**4**	**$71,654**	**$17,913**
BONNE TERRE, CITY OF	1	4	$71,654	$17,913
ST. LOUIS COUNTY	**149**	**1,006**	**$20,670,870**	**$3,399,189**
BRENTWOOD, CITY OF	6	38	$556,207	$97,801
CHESTERFIELD, CITY OF	1	7	$43,084	$6,155
FENTON, CITY OF	17	110	$1,744,809	$262,328
MARYLAND HEIGHTS, CITY OF	1	5	$118,456	$23,691
ST. LOUIS COUNTY *	48	347	$5,864,769	$817,961
ST. LOUIS, CITY OF	2	9	$126,402	$28,067
SUNSET HILLS, CITY OF	3	17	$208,924	$38,697
UNIVERSITY CITY, CITY OF	13	128	$1,366,944	$144,953
VALLEY PARK, CITY OF	58	345	$10,641,275	$1,979,536
STE. GENEVIEVE COUNTY	**4**	**20**	**$236,599**	**$49,788**
STE. GENEVIEVE, CITY OF	4	20	$236,599	$49,788
TANEY COUNTY	**3**	**6**	**$775,951**	**$387,975**
BRANSON, CITY OF	3	6	$775,951	$387,975

County/Community	Count of Mitigated	Sum of Total Losses	Sum of Total Paid	Sum of Average Paid
WASHINGTON COUNTY	**1**	**4**	**$72,028**	**$18,007**
ALTON, CITY OF	1	4	$72,028	$18,007
Grand Total	**509**	**3,392**	**$64,711,158**	**$10,985,882**

Source: FEMA PIVOT, April 5, 2022

Tornado Safe rooms (M6)

In Missouri, only flood mitigation projects are prioritized ahead of projects that mitigate tornadoes and high winds. Between 2013 and 2017, there were 62 tornado safe room projects funded in Missouri, primarily with PDM funding. Since 2018, 44 tornado safe room projects were funded, 84% through HMGP funding. **Table 7.18** presents a summary of the status of each project between 2012 and March 2022. Tornado safe rooms have proven to protect people from tornadoes and high winds when built to FEMA construction standards. Projects include safe rooms in homes that protect individual families as well as large-scale school and community safe rooms, which often meet multiple community objectives (e.g., serving as both a school gymnasium and a safe room).

The funding of tornado safe rooms supports the goals and objectives of this plan as indicated in **Table 7.18** The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies can be used to leverage funding.

Table 7.18. Tornado Safe Room Projects, 2013-2022

Year	No. of Approved Projects	No. of Completed Projects	No. of Pending/Ongoing Projects
2013	41	40	1
2014	6	6	0
2015	1	1	0
2016	7	0	7
2017	7	1	6
2018	6	6	0
2019	7	3	4
2020	4	2	2
2021	26	6	20
2022*	1	0	1
Total	**106**	**65**	**41**

*Data runs through March 22, 2022

Earthquake/High Wind Nonstructural Mitigation Projects (M8)

During February and March 2010, hundreds of Missourians took advantage of free earthquake public awareness events offered by SEMA and DNR's Division of Geology and Land Survey (DGLS). Free events were offered in St. Louis, Leasburg, Malden, Kennett, Piedmont, Jefferson City, Sikeston and Festus. At these public events, school children, residents and business planners asked questions and collected earthquake safety and mitigation information to protect their families and their property before a catastrophic earthquake occurs.

As noted earlier, SEMA regularly participates in the annual Great ShakeOut earthquake drills. These exercises are designed to promote awareness and increase earthquake preparedness nationwide. The Great Central U.S. ShakeOut is a multi-state drill spanning much of the central United States. For the

past 5 years, the State of Missouri has had an average of 426,258 participants, with 11,257 from State government. Categories lacking participants includes tribes/indigenous peoples, hotels and other lodgings, neighborhood groups, volunteer/service clubs, and agriculture/livestock sector. Announcement of the annual exercise was added to an existing mitigation action (#13) for distribution of public education materials.

Table 7.19. Great Shake Out Exercise Participants, 2018-2022

Category of Participants	2018	2019	2020	2021	2022	Average
Individuals/Families	280	913	386	306	450	**467**
Childcare and Pre-Schools	6,535	5,303	2,770	3,266	5,994	**4,774**
K-12 Schools and Districts	411,550	413,780	275,701	286,199	287,483	**334,943**
Colleges and Universities	30,165	20,868	18,533	27,963	21,650	**23,836**
Local Government	8,931	11,690	7,354	7,986	13,049	**9,802**
State Government	10,244	13,203	12,673	9,624	10,543	**11,257**
Federal/National Government (Including Military)	2,692	7,774	6,638	1,241	666	**3,802**
Tribes/Indigenous Peoples	0	0	0	0	0	**0**
Businesses	3,199	5,354	2,841	10,529	17,362	**7,857**
Hotels and Other Lodgings	0	0	0	0	0	**0**
Healthcare	18,720	21,448	18,689	23,726	23,966	**21,310**
Senior Facilities/Communities	1,806	1,479	225	688	1,101	**1,060**
Disability/AFN Organizations	355	589	73	384	420	**364**
Non-Profit Organizations	3,388	3,551	2,413	1,789	2,110	**2,650**
Neighborhood Groups	0	0	0	0	0	**0**
Preparedness Organizations	2,700	2,126	676	595	1,097	**1,439**
Faith-based Organizations	607	776	50	110	450	**399**
Museums, Libraries, Parks, etc.	590	860	800	915	758	**785**
Volunteer/Service Clubs	0	20	0	0	0	**4**
Youth Organizations	26	124	20	61	131	**72**
Animal Shelter/Service Providers	0	15	0	0	1	**3**
Agriculture/Livestock Sector	0	0	3	0	0	**1**
Volunteer Radio Groups	82	44	55	50	96	**65**
Science/Engineering Organizations	0	70	60	5	20	**31**
Media Organizations	500	503	503	500	501	**501**
Other	1,426	546	2	0	2,209	**837**
Total	**503,796**	**511,036**	**350,465**	**375,937**	**390,057**	**426,258**

Figure 7.15. Great Central US ShakeOut Drill, October 2016

Missouri ShakeOut earthquake drill takes place Thursday

By Kaitlyn Schumacher

Published: Oct. 20, 2022 at 5:14 AM CDT

SPRINGFIELD, Mo. (KY3) - You may not think earthquakes are much of a problem here in Missouri, but they could happen thanks to the New Madrid fault line in southeastern Missouri.

Source: KY3.com, October 20, 2022

Public Outreach (M13 and M14)

SEMA also makes a considerable effort to educate the public, local officials, government officials, schools, private associations, and businesses about the value and importance of mitigation programs (see **Figure 7.16**). SEMA offers mitigation workshops, participates in public forums, provides one-on-one counseling, presents at conferences, provides written materials, develops guidebooks and manuals, publishes success stories, sends out press releases, offers information on the Internet, and provides training materials to local emergency managers, earthquake program partners, floodplain managers, and businesses.

Figure 7.16. SEMA Newsletters –Floodplain Management E-Bulletin, Show-Me Response Program, SEMA Daily Brief

Missouri Floodplain Management E-Bulletin

September, 2022

Volume 5, Issue 1

Floodplain Management Staff:

Karen McHugh, CFM
State NFIP Coordinator
(573) 526-9129
karen.mchugh@sema.dps.mo.gov

Linda Olsen, CFM
Emergency Management Officer
(573) 526-9115
linda.olsen@sema.dps.mo.gov

Lynn Welch, CFM
Floodplain Management Officer
(573) 526-9135
lynn.welch@sema.dps.mo.gov

Lauren Imhoff
Floodplain Management Officer
(573) 526-
lauren.imhoff@sema.dps.mo.gov

Korie Otto
Misc. Professional/part-time
(573) 526-9169

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State Emergency Management Agency (SEMA) Floodplain Management Section

Issue 1 - FY 2022 - Floodplain Management E-Bulletin

It's the first quarter of Fiscal Year 2022, and time for the first FY22 *Missouri Floodplain Management E-Bulletin!* The entire Floodplain Management staff at the Missouri State Emergency Management Agency has been very busy this quarter working to help our Missouri communities recover from the July and August flooding events in the St. Louis Metropolitan area. We (Karen, Linda, Lynn, Lauren, and Korie) are looking forward to continuing to serve our NFIP communities to the best of our ability in FY22!

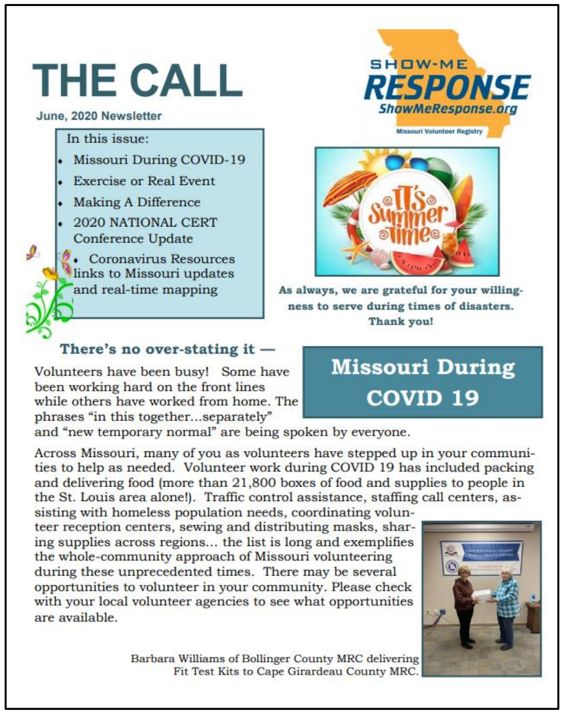
We're always looking for flooding photos, elevated structure photos, projects demonstrating stormwater management techniques and "green" projects, so please share them with us! Be sure to include your name, the location, and the date of the photo. Send photos to: karen.mchugh@sema.dps.mo.gov

NWS St. Charles, Mo

The Floodplain Management Section Welcomes Two New Employees!

The State Floodplain Management Section offers a warm welcome to Korie Otto and Lauren Imhoff, who recently joined our Floodplain Management team! Korie is working part-time to help the Floodplain Management Section with the many important tasks that keep our team organized. Lauren is the new Floodplain Management Officer; she will be working with Karen, Lynn, Linda, and Korie in all areas of Floodplain Management.

Welcome Korie and Lauren!!



THE CALL

June, 2020 Newsletter

SHOW-ME RESPONSE
ShowMeResponse.org
Missouri Volunteer Registry

In this issue:

- Missouri During COVID-19
- Exercise or Real Event
- Making A Difference
- 2020 NATIONAL CERT Conference Update
- Coronavirus Resources links to Missouri updates and real-time mapping

It's Summer Time

As always, we are grateful for your willingness to serve during times of disasters. Thank you!

Missouri During COVID 19

There's no over-stating it —

Volunteers have been busy! Some have been working hard on the front lines while others have worked from home. The phrases "in this together...separately" and "new temporary normal" are being spoken by everyone.

Across Missouri, many of you as volunteers have stepped up in your communities to help as needed. Volunteer work during COVID 19 has included packing and delivering food (more than 21,800 boxes of food and supplies to people in the St. Louis area alone!). Traffic control assistance, staffing call centers, assisting with homeless population needs, coordinating volunteer reception centers, sewing and distributing masks, sharing supplies across regions... the list is long and exemplifies the whole-community approach of Missouri volunteering during these unprecedented times. There may be several opportunities to volunteer in your community. Please check with your local volunteer agencies to see what opportunities are available.

Barbara Williams of Bollinger County MRC delivering Fit Test Kits to Cape Girardeau County MRC.

MISSOURI STATE EMERGENCY MANAGEMENT AGENCY

STATE WATCH CENTER

Current Conditions

Last Update 07:43 11/22/2022

www.sema.dps.mo.gov
@MoSEMA_
MissouriSEMA

Email: MOSEMA@sema.dps.mo.gov
Phone: 573-526-9100
Toll-Free: 800-298-6289

Specifically, SEMA staffs a mitigation booth and frequently makes presentations at the annual Emergency Management conference. In addition, to promote the concept and value of mitigation, SEMA issues press releases after FEMA makes HMA grant awards to notify the public of the mitigation project being funded, SEMA also publishes a quarterly newsletter that serves as a forum for emergency management news, including mitigation as well as an Annual Report and Blue Book report that document and share activities.

SEMA's public outreach efforts support all the goals of this plan, as increased public awareness is an objective under every goal (see **Table 7.15** and **Section 4.1** Hazard Mitigation Goals and Objectives). These efforts also support the State's mitigation strategy for ensuring continued effective use of resources through a wide array of partnerships (common partnerships for public outreach include public and private radio and television stations, public and private school organizations, and service organizations (e.g., Lions, Rotary, and Elks clubs) and volunteer organizations (American Red Cross).

Annual Hazard Mitigation Assistance Grants Application Assistance (M14)

As documented in **Section 4.2.4** Review and Progress of Mitigation Actions, Missouri has successfully secured funding for local mitigation plans and projects and State mitigation planning funds from the annual, nationally competitive Pre-Disaster Mitigation (PDM) grant program since 2002. The PDM program was replaced by the Building Resilient Infrastructure and Communities (BRIC) program in 2020. One of the reasons for this success is the hands-on technical assistance that SEMA provides to sub-applicants in their grant applications and benefit-cost analyses. This has been provided through annual contractor supported Hazard Mitigation Assistance grant workshops. These two-day workshops consist of HMA grants and BCA training. The BCA training was offered in 2013 and 2015. In addition to this training, the SEMA mitigation website provides links to FEMA's online BCA training as well as the BCA software.

This assistance supports all the goals of this plan by educating eligible State, local, and nonprofit entities in how they can secure funding for mitigation planning and projects. It also supports the State's mitigation strategy for ensuring continued effective use of resources by educating subapplicants about the process (as well as the State goals and objectives) to maximize the amount of BRIC (formally PDM funding granted to Missouri. Projects are screened during the application process to determine if they align with local and State mitigation goals.

Other Mitigation Actions

From time to time, other types of mitigation projects have been warranted if proven to be cost-effective solutions to problems. For example, based on documented damage to power lines, it became possible to bury those lines from the street to the meter on residences as a cost-effective mitigation measure to the adverse effects of severe weather (M12). These projects have been required to fulfill all the requirements for flood mitigation projects and possibly have had other additional requirements depending on the nature of the project.

Other actions implemented or obligated include flood elevations (M5), culvert/bridge replacements (M9), detention basins (M9), low water crossings (M9), electrical service line burials (M12), high wind retrofits (M7), generators (M13), and sirens (M8). The Missouri Department of Transportation designs new bridges and retrofits old bridges, including several in St. Louis, to resist seismic impacts (M7 and M9). To see how these actions meet the goals and objectives of the State, see **Table 7.15**. More information about these activities can be found in **Section 4.2** Mitigation Actions.

7.5.1. Mitigation Success

The State mitigation program encourages and motivates State and local government agencies, as well as the private sector and the general public, to mitigate hazards and establishes priorities for hazard mitigation programs in all areas of the State. To establish these priorities, the Hazard Mitigation Planning Team reviewed existing State statutes, ongoing mitigation initiatives, proposed mitigation initiatives/projects, and completed mitigation projects. The review of completed mitigation projects focused on the projects' overall success and contribution toward meeting the goals and objectives of the State and applicable local mitigation program.

Following are some examples of successful mitigation programs and projects. This list is not all-inclusive, but does include the efforts that have been deemed the most successful and/or beneficial to the overall mitigation program.

The State Hazard Mitigation Program

The State, through SEMA, has instituted an effective and comprehensive all-hazard mitigation program. Through the wise use of available federal Hazard Mitigation Assistance grants and State funds (e.g., Hazard Mitigation Grant Program, Public Assistance, Unmet Needs, Building Resilient Infrastructure and Communities, Flood Mitigation Assistance, Community Development Block Grants, Department of Natural Resources Stormwater Grants, Natural Resources Conservation Service, etc.) the State has been able to successfully mitigate many areas against the devastating effects of future disasters.

Hazard mitigation planning is a vital component of the State's disaster resistant community effort. SEMA mitigation staff schedule and conduct various trainings and workshops throughout the year to increase local knowledge and understanding of mitigation planning. A successful example of this is the Hazard Mitigation Plan Outline Workshops. Each year since 2015, three on-site planning workshops have been provided throughout the state focused specifically on use of the Plan Outline. This Plan Outline provides a framework/format for development of local hazard mitigation plan updates. It is organized with headings and subheadings to present meaningful information as well as ensure compliance with the local hazard mitigation planning requirements. Additional details are provided in **Section 4.6.3**.

History and a working relationship with State partners such as the State Historic Preservation Office and the Missouri Department of Conservations are indicators of SEMA's commitment to be able to prepare environmental documentation. Historically, SEMA has performed or reviewed all benefit-cost analyses for hazard mitigation grant applications and has successfully trained local jurisdictions to complete them. All current mitigation staff members have received formal FEMA benefit-cost training. New staff members will receive training at the availability of FEMA's training schedule.

During the 1993 Midwest floods, an interagency hazard mitigation team (IHMT) was formed. This team was composed of representatives from FEMA, SEMA, and various State agencies/departments (Governor's Office, Department of Economic Development, Department of Natural Resources, Department of Transportation, and others). The 1993, 1994, and 1995 buyout projects were selected, coordinated, and managed by a small committee appointed by the governor for this specific purpose. The wisdom in this approach can be found in the results as six months after hazard mitigation funding became available, all projects were approved.

This IHMT would later become the Hazard Mitigation Project Coordinating Group, then the State Hazard Mitigation Planning Team (SHMPT), and now the current State Risk Management Team (SRMT). While the name of this entity changed, its purpose remains the same. Following a significant disaster, hazard mitigation projects are coordinated through the representatives of the SRMT. This coordination is

primarily with representatives from the Department of Economic Development Community Development Block Grant section, the Missouri Department of Transportation, the Department of Natural Resources Historic Preservation office, and the U.S. Army Corps of Engineers. Other state and federal agencies are added to this group as the situation and mitigation issue dictates.

Ongoing since the 2008 floods, SEMA has participated in the Silver Jackets Program. This coordination program is an Interagency Flood Risk Management Team that consists of regional, state, USACE and FEMA partners and promotes the motto “Many Agencies, One Solution, Reducing Risk.” The name Silver Jackets comes from the different colored jackets which various agencies wear when responding to disasters, such as, USACE personnel wear red and FEMA personnel wear blue. The “Silver Jackets” represents a unified interagency team. SEMA and other agencies worked with the Silver Jackets Program to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The strategy planning sessions began in 2018. To date, 30 projects have been funded through this collaboration.

The mitigation process and the State’s mitigation initiatives are ongoing. SEMA’s mitigation staff in conjunction with other State and local agencies, continue to look for new opportunities and funding sources. The staff also continues to look at expanding existing mitigation initiatives and developing new ones. The primary focus for the use of disaster-related Hazard Mitigation Grant Program funds has been the flood buyout program and more recently the tornado safe room construction program.

The State also has an effective and proactive floodplain management program. Personnel from the Floodplain Management Section of SEMA are continually conducting assistance visits, trainings, and site inspections in communities throughout the State. These efforts ensure that local government, private enterprises, and the citizens of the State are aware of the benefits of participating in the National Flood Insurance Program, among other things.

As a result of the State’s mitigation program, local governments and private industries have formed partnerships to make the State and their communities and residents safer and more prepared for the next potential disaster. Their actions will help ensure that future disasters have less of an impact on lives, property, and infrastructure in their communities and the State.

Missouri Community Buyout Program

In the aftermath of the summer of 1993 flood, the State launched an unprecedented statewide hazard mitigation effort in the form of the Community Buyout Program. This was a voluntary program designed to acquire residential properties in the floodplain and move residents out of harm’s way. The buyout program utilized a mix of federal funds, including funds from the Hazard Mitigation Grant Program, Public Assistance, and Missouri Community Development Block Grants. Then-Governor Mel Carnahan conservatively estimated the buyout program would save Missouri an estimated $200 million in flood fighting costs, Individual Assistance, and flood insurance claims over the next 20 years.

But, no one could predict Missouri would have the opportunity to test the buyout’s effectiveness as quickly as it did when the spring 1995 flood, the third worst flood on record in many places, struck. Due to the buyout program, there were some 2,000 families no longer living in the floodplain. Removing these flood prone properties from harm’s way saved millions in disaster assistance and emergency protective measures statewide.

Participating buyout communities were able to focus their efforts on the flood response. They did not have to use their limited resources on evacuating residents or sandbagging structures to save private property in the floodplain. Likewise, claims for flood insurance and applications for assistance, such as Small Business Administration and Individual and Family Grant (IFG) Program loans, were minimized.

The flood of 1995 was significantly equal to the flood of 1993 in the majority of communities that undertook a flood buyout program after the 1993 flood. The cost of human suffering was dramatically reduced in 1995, however, thanks to the buyout program and the associated demolition of about two-thirds of the flood-prone homes after the flood of 1993. This meant that fewer people were in harm's way during the flood of 1995, thanks to Missouri's highly successful buyout program. Flood insurance claims payments on flood buyout properties, totaled more than $22.6 million for the 1993 and 1995 flood events. As a result of the buyout program these claims will never be paid out again.

The flood of May 2007 (DR-1708) drew parallels to the 1993 flood, causing significant damage along the Missouri River, and generated more success stories for the buyout program. In one example, 17 properties had been acquired in the City of Tracy for approximately $450,000. In some areas of Tracy, recent water levels exceeded those of the 1993 flood. Had they not been removed, those 17 homes would have been inundated with flood waters and cost the city and homeowners hundreds of thousands of dollars. Additionally, the spring and summer floods of 2008 (DR-1749 and DR-1773) impacted eastern Missouri. The loss avoidance study conducted by FEMA following these flood events, as presented in **Section 7.4.2**, demonstrates the cost-effectiveness of the buyout program with losses avoided valued at $96.3 million and a return on investment of 21.2 percent.

Over the last five years, there continues to have been successful property acquisitions. There were 198 applications, with a few withdrawn. There were 126 projects closed with $68M in federal dollars awarded. There were 7 in four counties for FMA -FY17 funding including Franklin, Phelps, St. Charles and St. Louis Counties. There were four for FMA-FY18 funding in Cass and Franklin Counties. There were 113 properties closed for DR-4317 spanning 13 counties including Barry, Cape Girardeau, Carter, Clay, Douglas, Franklin, Howell, Phelps, Ripley, St. Louis City, St. Louis County, Ste. Genevieve and Taney Counties. There was one in Phelps County for DR-4318. There was one in St. Charles County for DR-4451.

Floods occurring in the winter of 2015/2016 (DR-4250 and EM-3374) were also devastating to the State. A highly unusual heavy rainfall event from December 26 through 29 dropped 7.5-10 inches of rain along a 60-mile wide corridor extending from just south of Joplin to St. Louis. Rivers and streams reacted quickly to the post-Christmas rainfall event, and flash flooding was widespread with hundreds of water rescues reported, especially over the southern half of the state. There were 27 flood fatalities reported in 2015. This was more than the combined number for the previous 7 years and represented the highest number since 1993, the highest number on record for the State. A loss avoidance analysis was conducted for this flood event, as presented in **Section 7.4.2.**

Table 7.20 presents the number of structures acquired and demolished by County with each associated mitigation project. There have been 201 property acquisitions completed in Missouri since 2018.

Table 7.20. Missouri's Community Buyout Program Success

County	Mitigation Project Identifier	Year	Number of Properties
Barry	DR-4317-0042-R	2021	4
Bollinger	DR-1403-0011-R	2002	26
	DR-1736-0002-R	2007	4
Boone	DR-0995-0016-R	1993	7
	DR-0995-0021-R	1993	4
Buchanan	DR-0995-0035-R	1993	37
	DR-1635-0010-R	2006	1
Marion	DR-0995-0004-R	1993	144
	DR-0995-0030-R	1993	37
	DR-1736-0003-R	2007	15
Mississippi	DR-1980-0079-R	2011	19
	DR-1980-0079-R	2018	19
Moniteau	FMA-PJ-07MO-1997001	1997	7
Montgomery	DR-0995-0005-R	1993	61

County	Mitigation Project Identifier	Year	Number of Properties
Butler	DR-1403-0005-R	2002	36
	DR-1676-0021-R	2007	10
	FMA-PJ-07-MO-2006-002	2006	3
Callaway	DR-0995-0003-R	1993	6
	DR-1054-0001-R	1995	2
Cape Girardeau	DR-1054-0001-R	1995	107
	DR-1403-0004-R	2002	2
	DR-1980-0074-R	2011	11
	DR-4317-0012-R	2020	2
	FMA-PJ-07-MO-2013-005	2013	1
Carroll	DR-0995-0011-R	1993	96
	DR-1253-0005-R	1998	6
Carter	DR-4317-0045-R	2021	14
	DR-4317-0040-R	2021	9
Cass	DR-1463-0004-R	2003	4
	DR-1463-0005-R	2003	22
	FMA-PJ-07-MO-2018-003	2019	3
Christian	RFC-PJ-07-MO-2009-001	2009	1
Clark	DR-0995-0014-R	1993	43
	DR-0995-0025-R	1993	7
Clay	DR-0995-0026-R	1993	57
	DR-1023-0001-R	1994	11
	DR-1253-0001-R	1998	5
	DR-1253-0004-R	1998	7
	DR-4238-0018-R	2015	1
	DR-4238-0018-R	2018	1
	DR-4317-0041-R	2022	50
	FMA-PJ-07-MO-2013-002	2013	2
	FMA-PJ-07-MO-2016-007	2016	4
Cole	DR-0995-0003-R	1993	161
	DR-1412-0010-R	2002	1
Daviess	DR-0995-0041-R	1993	271

County	Mitigation Project Identifier	Year	Number of Properties
	DR-0995-0037-R	1993	16
Newton	DR-0995-0036-R	1993	60
	DR-1403-0002-R	2002	7
	DR-1412-0009-R	2002	1
	FMA-PJ-07-MO-2019-002	2020	1
Nodaway	DR-0995-0038-R	1993	1
Perry	DR-0995-0013-R	1993	32
Phelps	DR-0995-0040-R	1993	25
	DR-4317-0020-R	2021	4
	FMA-PJ-07-MO-2017-006	2018	6
Platte	DR-0995-0018-R	1993	1
	DR-0995-0031-R	1993	17
	FMA-PJ-07-MO-2016-005	2016	1
Pulaski	DR-1006-0002-R	1993	19
Ray	DR-1253-0002-R	1998	3
Reynolds	DR-1403-0012-R	2002	26
	DR-1412-0005-R	2002	28
Ripley	DR-1676-0018-R	2007	20
	DR-1980-0036-R	2011	1
	FMA-PJ-07-MO-2013-001	2013	1
	DR-4317-0044-R	2021	12
Scott	DR-1054-0002-R	1995	29
St. Charles	DR-0995-0001-R	1993	1407
	DR-0995-0017-R	1993	9
	DR-1054-0003-R	1995	8
	DR-1728-0001-R	2007	7
	DR-4451-0012-R	2021	3
	FMA-PJ-07MO-1997004	1997	1
	FMA-PJ-07MO-1998004	1998	1
	FMA-PJ-07-MO-2008-001	2008	9
	FMA-PJ-07-MO-2013-003	2013	3
	FMA-PJ-07-MO-2014-003	2014	3

County	Mitigation Project Identifier	Year	Number of Properties
Douglas	DR-4317-0014-R	2020	1
Franklin	DR-0995-0033-R	1993	5
	DR-0995-0034-R	1993	34
	DR-0995-0039-R	1993	2
	DR-1023-0002-R	1994	4
	DR-1253-0010-R	1998	19
	DR-1256-0003-R	1998	2
	DR-1328-0001-R	2000	17
	DR-1412-0001-R	2002	11
	DR-1676-0012-R	2007	21
	DR-1708-0001-R	2007	1
	DR-4317-0035-R	2021	18
	FMA-PJ-07-MO-2013-004	2013	3
	FMA-PJ-07-MO-2016-006	2016	37
Gasconade	DR-0995-0037-R	1993	6
	FMA-PJ-07-MO-2017-001	2018	1
Greene	DR-1253-0012-R	1998	2
	DR-1256-0005-R	1998	1
	DR-1328-0002-R	2000	2
	DR-1412-0004-R	2002	6
	DR-1760-0001-R	2008	5
	FMA-PJ-07-MO-2006-001	2006	2
Harrison	DR-0995-0037-R	1993	1
Howard	DR-0995-0022-R	1993	73
Howell	DR-1006-0003-R	1993	2
	DR-1403-0003-R	2002	6
	DR-1412-0008-R	2002	3
	DR-4317-0043-R	2021	4
Iron	DR-1403-0014-R	2002	7

County	Mitigation Project Identifier	Year	Number of Properties
	FMA-PJ-07-MO-2014-004	2014	2
	FMA-PJ-07-MO-2014-005	2014	1
	FMA-PJ-07-MO-2015-002	2015	2
	FMA-PJ-07-MO-2016-009	2016	2
	FMA-PJ-07-MO-2017-004	2018	2
	FMA-PJ-07-MO-2019-001	2020	2
	SRL-PJ-07-MO-2008-001	2008	1
St. Clair	DR-0995-0001-R	1993	2
	DR-1023-0003-R	1994	1
St. Francois	DR-1403-0007-R	2002	7
St. Louis	DR-0995-0001-R	1993	1
	DR-0995-0007-R	1993	550
	DR-0995-0008-R	1993	19
	DR-0995-0009-R	1993	9
	DR-1023-0003-R	1994	3
	DR-5256-0003-R	1998	1
	DR-5256-0009-R	1998	1
	DR-1403-0006-R	2002	1
	DR-1676-0019-R	2007	6
	DR-1749-0007-R	2008	24
	DR-1773-0003-R	2008	2
	DR-1773-0004-R	2008	12
	DR-1822-0027-R	2009	3
	DR-4317-0009-R	2019	1
	DR-4317-0038-R	2020	3
	DR-4317-0019-R	2022	3
	FMA-PJ-07-MO-2004-001	2004	4
	FMA-PJ-07-MO-2014-001	2014	11
	FMA-PJ-07-MO-2014-002	2014	3

County	Mitigation Project Identifier	Year	Number of Properties
	DR-1412-0011-R	2002	5
	DR-5270-0002-R	1999	6
Jackson	DR-0995-0028-R	1993	5
	DR-1253-0003-R	1998	12
	DR-5256-0002-R	1998	26
Jasper	DR-1980-0077-R	2011	3
	DR-4317-0034-R	2021	0
	DR-1980-0077-R	2018	3
Jefferson	DR-0995-0002-R	1993	211
	DR-0995-0012-R	1993	220
	DR-0995-0019-R	1993	19
	DR-0995-0020-R	1993	25
	DR-0995-0042-R	1993	1
	DR-1463-0001-R	2003	3
	DR-1736-0004-R	2007	13
	DR-4317-0015-R	2021	9
	FMA-PJ-07MO-1997002	1997	1
	FMA-PJ-07MO-1998002	1998	3
	FMA-PJ-07MO-1998005	1998	3
	FMA-PJ-07MO-1999001	1999	6
	FMA-PJ-07MO-2000001	2000	4
	FMA-PJ-07MO-2001001	2001	5
	FMA-PJ-07-MO-2005-001	2005	1
	FMA-PJ-07-MO-2016-002	2016	2
Lewis	DR-0995-0023-R	1993	2
	DR-0995-0027-R	1993	12

County	Mitigation Project Identifier	Year	Number of Properties
	FMA-PJ-07-MO-2015-001	2015	1
	FMA-PJ-07-MO-2016-001	2016	8
	FMA-PJ-07-MO-2016-003	2016	1
	FMA-PJ-07-MO-2016-004	2016	1
	FMA-PJ-07-MO-2016-008	2016	3
	FMA-PJ-07-MO-2016-010	2016	1
	FMA-PJ-07-MO-2017-003	2018	0
	FMA-PJ-07-MO-2017-008	2018	7
	FMA-PJ-07-MO-2018-002	2019	2
	PDMC-PJ-07-MO-2005-003	2005	2
	PDMC-PJ-07-MO-2009-004	2009	5
	PDMC-PJ-07-MO-2009-006	2009	2
	PDMC-PJ-07-MO-2011-006	2011	1
	RFC-PJ-07-MO-2008-001	2008	1
Ste. Genevieve	DR-0995-0006-R	1993	40
	DR-0995-0010-R	1993	41
	DR-4317-0036-R	2020	1
Stoddard	DR-0995-0010-R	1993	2
Stone	DR-0995-0008-R	1993	1
Taney	DR-1054-0002-R	1995	2
	DR-1412-0007-R	2002	7
	DR-1980-0002-R	2011	9
	DR-1980-0003-R	2011	5
	DR-4317-0037-R	2021	16
Texas	PDMC-PJ-07-MO-2003-004	2003	3
	PDMC-PJ-07-MO-2005-019	2005	1

County	Mitigation Project Identifier	Year	Number of Properties
	DR-1708-0005-R	2007	8
Lincoln	DR-0867-0004-R	1990	89
	DR-0995-0015-R	1993	45
	DR-0995-0029-R	1993	376
	PDMC-PJ-07-MO-2005-005	2005	15
Madison	DR-1006-0001-R	1993	27
	DR-1253-0007-R	1998	2
	DR-1253-0008-R	1998	26
	DR-1256-0002-R	1998	16
	DR-1270-0001-R	1999	7
	DR-1270-0002-R	1999	1
	DR-1403-0013-R	2002	20
	DR-1403-0015-R	2002	8
	DR-5270-0003-R	1999	5
	DR-5270-0004-R	1999	3
	DR-5270-0006-R	1999	8
Warren	DR-0995-0024-R	1993	20
	DR-0995-0032-R	1993	14
Wayne	DR-0995-0045-R	1993	9
	DR-1006-0007-R	1993	19
	DR-1023-0005-R	1994	2
	DR-1054-0008-R	1995	10
	DR-1403-0008-R	2002	12
	DR-1676-0010-R	2004	9
	DR-1676-0015-R	2004	18
	DR-1749-0009-R	2008	4
	FMA-PJ-07MO-1997003	1997	10
	FMA-PJ-07MO-1998003	1998	6
	RFC-PJ-07-MO-2009-002	2009	1
Webster	DR-1676-0013-F	2007	1
	PDMC-PJ-07-MO-2005-025	2005	1
TOTAL			**5,432**

Source: State Emergency Management Agency

Since the 1993 floods, over 5,750 primary residences have been acquired through the buyout program. This voluntary program has allowed families in flood-prone areas to relocate out of harm's way and reduced disaster-related costs. The acquired properties were placed in public ownership with deed restrictions to ensure that future use of these lands will not put the lives of Missouri residents at risk from flood disasters. The document *Past Mitigation Projects* contains Community Buyout Program statistics through fiscal year 2009.

Some communities have continued this program by using local funds to acquire flood-prone properties. This is a clear example of the positive impact of advertising mitigation success stories. Because of the success of this program, the acquisition of flood-prone structures continues to be a priority for the use of hazard mitigation funds available to the State.

For additional information on the tremendous success of the Missouri Buyout Program, refer to the SEMA and the FEMA library for following documents:

- Loss Avoidance Study: Eastern Missouri, Building Acquisition Part One: General Overview and Part Two: Detailed Methodology"
- Stemming the Tide of Flood Losses
- Missouri Flood Mitigation Project
- Success Stories from the Missouri Buyout Program

As previously mentioned, through the Silver Jackets program, SEMA has proposed, and was awarded funding in late 2017, to develop a Missouri Flood Buyout Strategy to guide the selection process for

distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy identified a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy ranked the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state.

Safe Room Construction Program

As of May 2023, 269 tornado safe room projects have been completed or are in progress utilizing FEMA Hazard Mitigation Assistance grants totaling over $266 Million. The State of Missouri is committed to setting a standard in the State for safe room construction, ensuring that all funded safe rooms are constructed in accordance with FEMA design standards. The Loss Avoidance Assistance Tool described in **Section 7.4.2** has functionality to assess the effectiveness of the safe room program.

SEMA's Mitigation Management Section Staff routinely perform closeout visits and make sure the community has all the required paperwork easily accessible if a federal audit is conducted for the project. Many of the communities hold groundbreaking or ribbon cutting ceremonies to commemorate these mitigation projects (see **Figure 7.17, Figure 7.18 and Figure 7.19**).

Figure 7.17. Texas County Memorial Hospital

Figure 7.18. Bollinger County Safe Room Ribbon Cutting

Bollinger County FEMA Safe Room holds Ribbon Cutting - Dille Pollard Architecture Firm

Visit

Figure 7.19. Gainesville School District in Ozark County

OZARK COUNTY Times

Tuesday, June 7, 2022

BREAKING GROUND ON $3.7 MILLION ADDITION: Gainesville School begins construction on new large, front addition funded by grants and interest-free loan

Thu, 10/28/2021 - 9:55am admin

Gainesville School Board members, current superintendent Justin Gilmore and former superintendent Jeff Hyatt put shovels to dirt Friday in a groundbreaking that marked the launch of construction on the school's $3.7 million addition. From left: Hyatt, board members Mason Eslinger, Robby Wehrath, Jerry Kiger and Corey Hillhouse, Gilmore, board members Heather Bushner, board vice president Jabet Wade and board president Marti Warden.

Gainesville School held a groundbreaking ceremony Friday for its new $3.7 million addition, which includes $2 million in FEMA funding for a storm shelter and a $1 million interest-free loan offered by White River Valley Electric Cooperative through a Rural Economic Development Loan and Grant Program. Pictured, front row, from left, are junior high and high school assistant principal Trevor Hicks; elementary school principal Erin Swofford; junior high and high school principal Clint Hall; Gainesville School Board member Mason Eslinger; Community Foundation of the Ozarks Central Region manager Joe Kammerer; Gainesville School Board members Robby Wehrath, Jerry Kiger, Corey Hillhouse, Heather Bushner, vice president Jabet Wade and president Marti Warden; superintendent Justin Gilmore; 33rd Missouri District Sen. Karla Eslinger; 155th District State Rep. Travis Smith; White River Valley Electric Cooperative key account and economic development specialist Devin Sonnenfelt; WRVEC CEO Chris Hamon; WRVEC Board member and former Gainesville superintendent Dr. Jeff Hyatt; WRVEC manager of communications and member engagement Cassie Cunningham; WRVEC Board member Jim Kyle; U.S. Sen. Roy Blunt field staff member Will Wheeler; SCOCOG

By Jessi Dreckman,
jessi@ozarkcountytimes.com

Fifteen golden shovels hit the dirt Friday, Oct. 22, in front of Gainesville High School, signaling the official groundbreaking for Gainesville's new $3.7 million, 8,000-square-foot addition.

The new structure, which will sit directly in the center front of the current building, will include a new facade, locker rooms, offices, a storage room and multi-use common area. It will also serve as a school and community storm shelter able to withstand 250-mph winds. As required by the Federal Emergency Management Agency, the source of some of funding for the building, the storm shelter will be open for students and staff during the school day as well as for nearby residents anytime a tornado warning is issued – even outside school hours.

Gainesville superintendent Justin Gilmore said last week that construction has begun and will continue through this school year.

He hopes the work can be finalized before the start of the 2022-23 school year.

The groundbreaking included a program in the newly renovated Gainesville High School gym, where Gilmore, White River Valley Electric Cooperative economic specialist Devin Sonnenfelt and Missouri 33rd District Sen. Karla Eslinger addressed the audience.

FEMA grant award and additional plans

Gilmore said that former Gainesville Superintendent Jeff Hyatt, who also attended the ceremony, originally "got the ball rolling" for the FEMA shelter grant in 2017, and after his retirement, Gilmore and the current school board took the reins and carried it through. The South Central Ozark Council of Governments (SCOCOG) also became involved early on and was instrumental in the intense and time-consuming grant-writing process.

The district was notified in October 2020 that it had received the grant, which includes a total of $2,046,816 in FEMA funding to build the storm shelter onto the front of the

Another specific example of the success of this program is the monolithic dome safe room for the Niangua R-V School District in Webster County. This dome-shaped safe room doubles as a preschool classroom and is the first of its kind approved for FEMA funding. This safe room, funded out of the FY2006 appropriation of the PDM grant program will hold approximately 400 people and meets FEMA's criteria for the design and construction of community safe rooms. The new dome-shaped building cost just over $300,000. Monolithic domes are known not only for their safety, but also for their energy efficiency. A dome can cost as much as 50 percent less to heat and cool than a traditional structure of the same size. Also, because of the materials used in their construction, they are also fire-safe.

In 2020, SEMA applied for BRIC State Allocation funding for a safe room project at High Point R-III School District. That project was selected for further review and approved but had to withdraw due to time frame of approval. In 2021, Gasconade C-IV Safe Room was approved but also had to withdraw due to time frame of approval.

Local Mitigation Planning Program

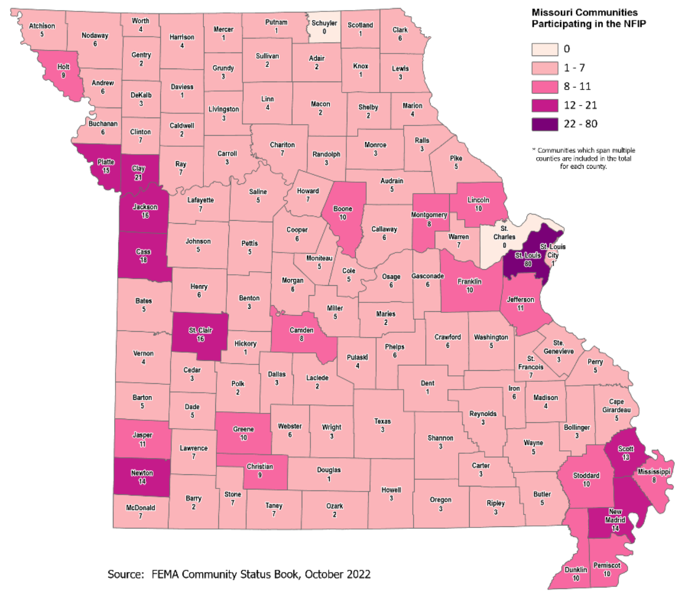
This project was established to develop local hazard mitigation plans that meet the requirements of the Disaster Mitigation Act of 2000. Funding for local hazard mitigation plans has come primarily from Hazard Mitigation Grant Program funds and BRIC funds. This effort showcases the coordination between the State and the Regional Planning Commissions and Councils of Government throughout the State, the represented local communities, business and industry, as well as concerned private citizens. Currently, there are 106 FEMA-approved local hazard mitigation plans in Missouri, representing 106 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives.

National Flood Insurance Program

In Missouri, the National Flood Insurance Program (NFIP) has shown remarkable progress over time. When SEMA took responsibility for administration of the State's floodplain management program in 1995, there were 523 jurisdictions in the National Flood Insurance Program. As of May 2023, there are 685 participating jurisdictions with the last community in the emergency program converted as of March 2023. There are 15 additional communities in the process of joining. All the participating communities have established local floodplain management ordinances to help them administer the program.

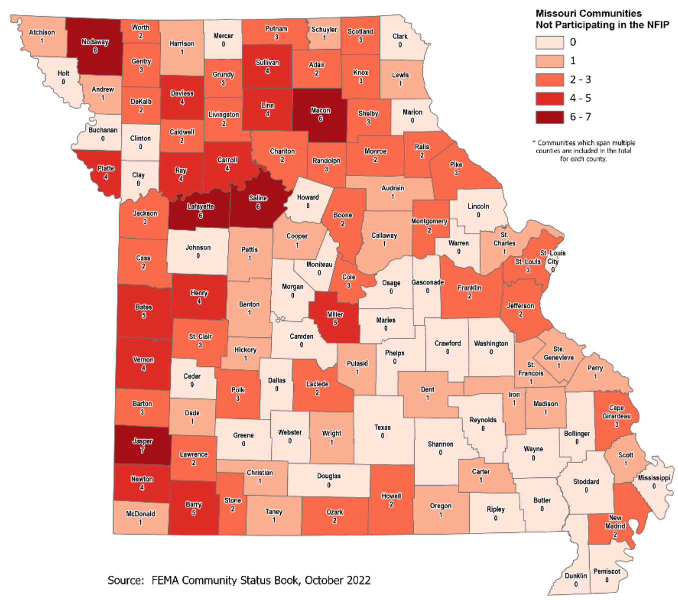
Of the 1,096 jurisdictions in Missouri, 396 are not in the National Flood Insurance Program (NFIP) that have hazard areas identified. Through the Risk MAP program and Paper Inventory Reduction (PIR) program, SEMA will have 100% of the State with updated and identified flood hazard areas by 2024. There will be 2D models statewide by 2027 with continued funding through these programs. With the identification of new flood hazard areas, communities are learning of their flood risk and opportunities to join the NFIP. The locations of participating and nonparticipating communities are mapped by county in **Figure 7.20** and **Figure 7.21**, respectively.

Figure 7.20. Missouri Communities Participating in NFIP



Source: FEMA Community Status Book, October 2022

Figure 7.21. Missouri Communities Not Participating in NFIP



Source: FEMA Community Status Book, October 2022

Floodplain Management Outreach

Devastating flood events continue to occur within the State, requiring massive cleanup efforts that last for several weeks and/or months. Because of excellent outreach efforts following flood events, many communities have a head start in performing substantial damage evaluations immediately after the waters recede and expediting the recovery process for dozens of affected communities. Outreach efforts included notification to local floodplain managers in NFIP communities accompanied with an updated 23-page "Missouri Flood Damage Assessment Packet". The packet included information on:

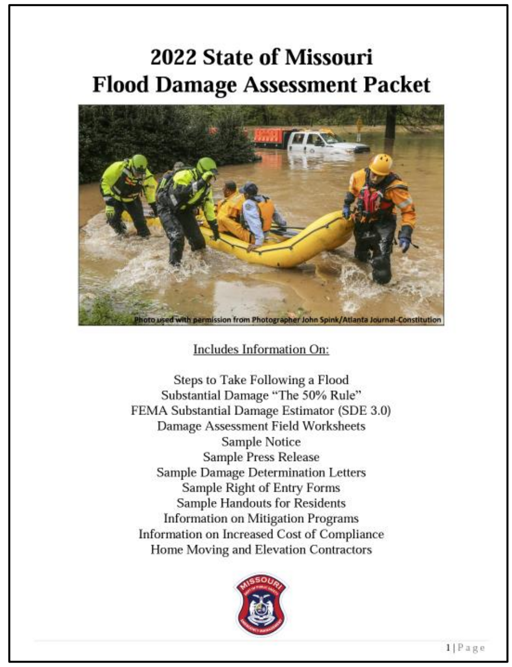

2022 State of Missouri
Flood Damage Assessment Packet

Photo used with permission from Photographer John Spink/Atlanta Journal-Constitution

Includes Information On:

Steps to Take Following a Flood
Substantial Damage "The 50% Rule"
FEMA Substantial Damage Estimator (SDE 3.0)
Damage Assessment Field Worksheets
Sample Notice
Sample Press Release
Sample Damage Determination Letters
Sample Right of Entry Forms
Sample Handouts for Residents
Information on Mitigation Programs
Information on Increased Cost of Compliance
Home Moving and Elevation Contractors

1 | Page

- Steps to take following a flood
- Substantial Damage "The 50% Rule"
- FEMA Substantial Damage Estimator (SDE 3.0)
    - Updated Version of SDE
- Damage Assessment Field Worksheets
- Sample Notice
- Sample Press Release
- Sample Damage Determination Letter
- Sample Right of Entry Forms
    - Newly Added
- Sample Handouts for Residents
- Information on Mitigation Programs
- Information on Increased Cost of Compliance
- Home Moving and Elevation Contractors
    - Newly Added

This outreach process is an ongoing effort. The packet was updated recently for use in 2022.

MoDNR Stormwater Improvements

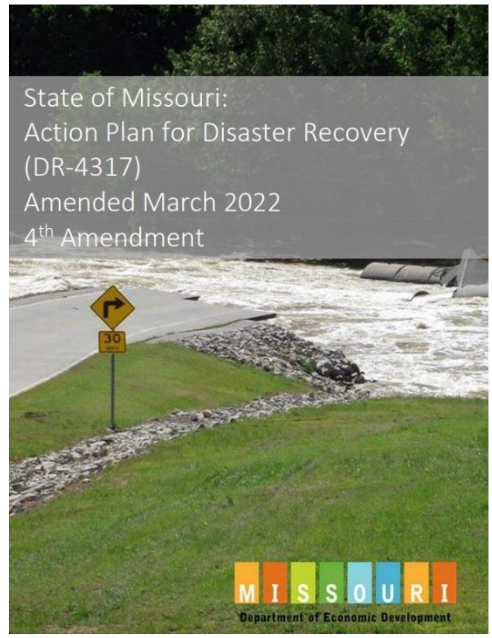
In 2001, the Missouri Department of Natural Resources (MoDNR) awarded more than $9.9 million to 46 Missouri communities for stormwater improvements. Of these 46 communities, 7 of them had populations of 3,000 or less. Funding for these grants came from bond issues approved by Missouri voters in 1988 and 1998 for improvements to stormwater, wastewater treatment, and public drinking water systems.

Types of projects approved by DNR included, but were not limited to:

- Drainage modifications to prevent pooling water, reduce streambank erosion, reduce localized flooding, and improve discharge water quality
- Buyout and demolition of flood-prone homes
- Replacement of undersized drainage systems to prevent flooding of houses and streets
- Channel stabilization and drainage improvement
- Modification of existing detention basin outlet for better storage capacity and to help avert downstream flooding
- Development of city- and county-wide stormwater management plans
- Construction of stormwater collection and control systems

- Combinations of biostabilization measures and upstream detention to alleviate existing erosion and to prevent future channel degradation based on anticipated future development conditions
- Construction of new storm sewer systems

CDBG Disaster Supplemental Funding



In 2018, the U.S. Department of Housing and Urban Development (HUD) awarded Missouri $58.5 million in Community Development Block Grant disaster recovery (CDBG–DR) funds to help alleviate the unmet housing, infrastructure, and economic revitalization needs triggered by the floods of 2017 (DR-4317). Priority for the funding was to first address unmet housing needs. Unmet need was discovered in the areas of housing, public infrastructure and economic revitalization. HUD then allocated an additional $9,847,018 to the State for Unmet Needs for Infrastructure. With the additional allocation for Unmet Needs for Infrastructure, the State's total HUD CDBG-DR allocation in response to DR-4317 was $68,382,018.

Projects funded by these CDBG-DR funds have included: state administration, planning activities for the Ozark Foothills, Meramec, and Bootheel Regional Planning Commissions, planning activities for Wayne and Butler Counties, acquisitions and construction of new housing, improvements to flood and drainage facilities, new sidewalks, storm sewers and street/road improvements.

In 2019, HUD awarded Missouri $30,776,000 for DR-4451. HUD Designated St. Charles county, Holt County (Zip Code 64437), and Cole County (Zip Code 65101) as Most Impacted and Distressed areas and mandated that 80% of the allocation be used to their benefit. Projects funded by these CDBG-DR funds have included: affordable multi-family rental housing, infrastructure to support recovery efforts, construction of new housing, down payment assistance, homeowner assistance counseling and rehabilitation, acquisitions, and planning.

Reservoirs, Levees, and Flood Walls

During the Great Flood of 1993, flood damage reduction structures prevented an estimated $19.1 billion in potential additional damage, according to the May 26, 1994, *Draft Report of the Interagency Floodplain Management Review Committee*. Of that, it is estimated that at least $11.5 billion damage was prevented along the Missouri River: $7.4 billion was attributed to management of floodwater stored in reservoirs and $4.1 billion was attributed to levees. Reservoirs, levees, and flood walls prevented damage of approximately $5.6 billion in Kansas City.

Another study, conducted by a former U.S. Army Corps of Engineers (Corps) District engineer, estimated flood damage in the St. Louis district of the Corps at $1.4 billion. At the same time, the study estimated damage prevented by federal flood damage reduction efforts at $5.4 billion. Thus, an 80 percent reduction in potential damage was achieved in the St. Louis Corps district.

Missouri Bridges Constructed to Withstand Earthquakes

The Missouri Department of Transportation (MoDOT) began designing bridges to resist seismic hazards in 1990. However, many of the nearly 2,000 bridge structures in earthquake-prone portions of the State

were not designed to resist seismic induced forces. Several structures in St. Louis that were designed and constructed before 1990 have been retrofitted to resist seismic induced forces.

Construction of the retrofit of Poplar Street Bridge in St. Louis, Missouri was completed in late 2002 at a cost of $6.2 million. This 2,165-foot bridge carries more than 130,000 vehicles per day across the Mississippi River.

Figure 7.22. Pier 1 Retrofits on the Poplar Street Bridge, St. Louis, Missouri

Source: Seismic Retrofit of the Popular Street Bridge, Mark R. Capron

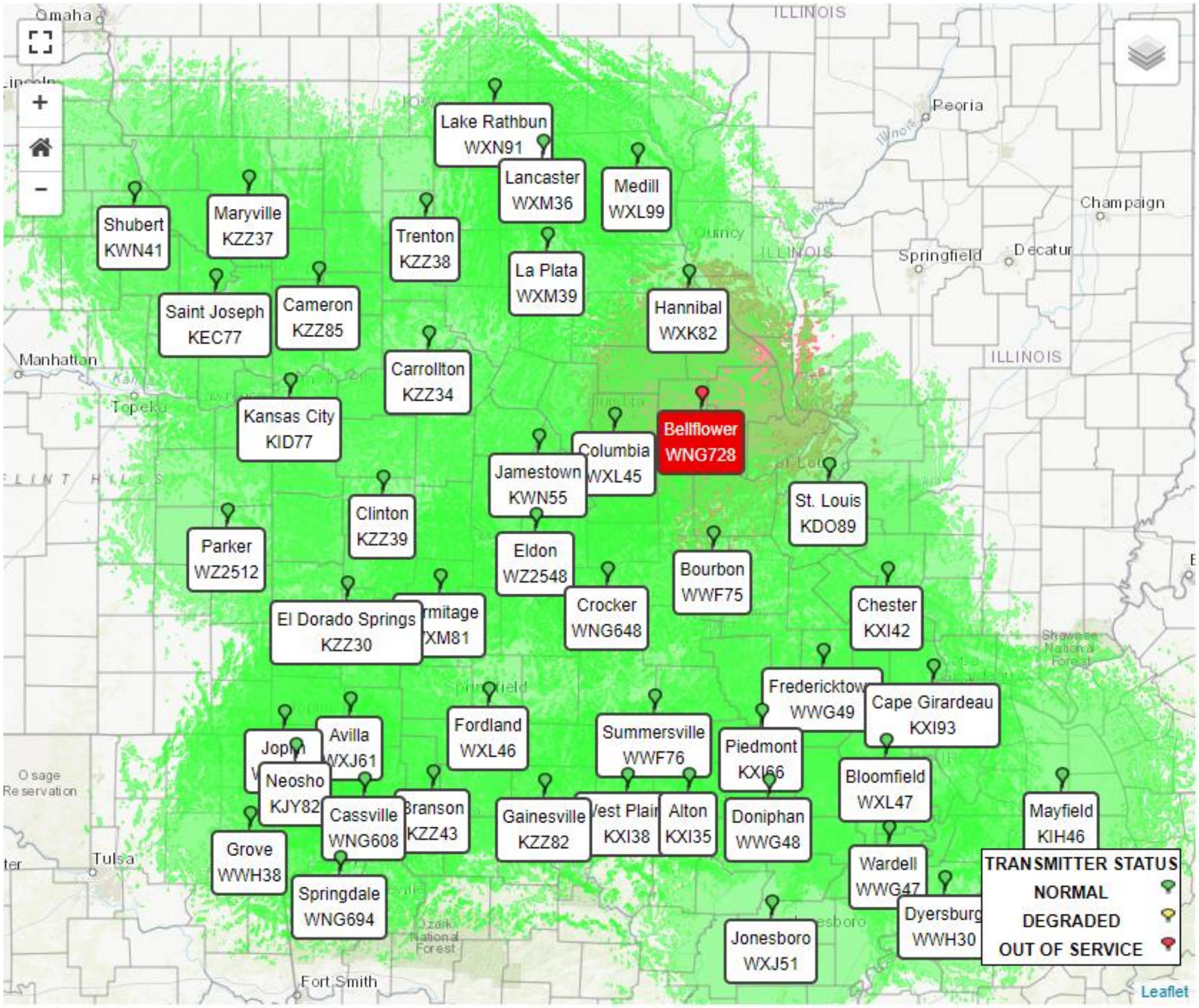
National Oceanic and Atmospheric Administration Weather Radio All Hazards

The National Oceanic and Atmospheric Administration (NOAA) Weather Radio All Hazards (NWR) is an all-hazards public warning system that broadcasts forecasts, warnings, and emergency information 24 hours a day. The National Weather Service has responsibility for the NWR. Tone alert radios receive the broadcasts and can be programmed to sound when severe weather watches, warnings, or other critical information is broadcast. They are designed to automatically sound when warnings are issued.

The NWR project increased the number of NOAA weather warning transmitters in Missouri from 10 in 1998 to 34 in 2007 to 45 in 2022 (State Propagation (weather.gov)). However, the transmitter in Bellflower, serving 11 counties, is temporarily out of service. Every county in the State is covered by one or more NOAA Weather Radio transmitters. However, due to hills and other issues that cause signal blockage, there are areas that cannot pick up a strong signal. Approximately 95 percent of the State can receive NWR broadcasts (see **Figure 7.23**). This success story is a result of the cooperative efforts of State, federal, and local government; private citizens; business and industry; and the State's electric cooperatives.

The expanded severe weather warning coverage provided by these transmitters benefits everyone in the State. By providing early warnings for severe weather, these transmitters enable people in the affected areas to take cover and protect themselves from severe weather.

Figure 7.23. Missouri's NOAA Weather Radio Coverage



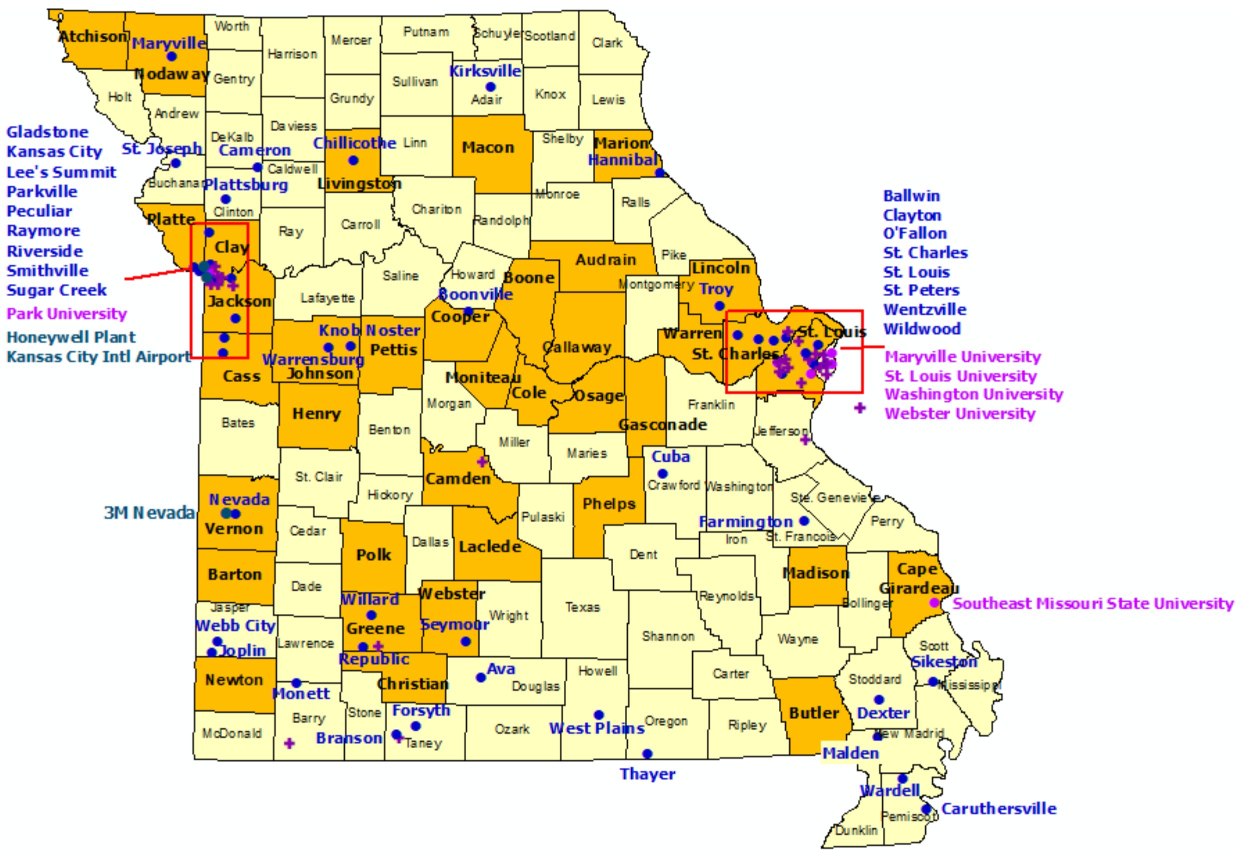
National Oceanic and Atmospheric Administration (NOAA) StormReady Program

Missouri has consistently made progress in preparing its communities for severe weather. Storm Ready sites have increased from 28 in 2004 to 91 in 2022:

- 2004 - 7 counties, 20 communities, and 1 commercial site in the StormReady program.
- 2007 - 16 counties, 25 communities, 1 commercial site (there are only 5 nationwide), and 1 university.
- 2010 - 16 counties, 34 communities, 2 commercial sites, 1 university, and 2 supporters.
- 2018 - 29 Counties, 50 Communities, 2 Government/Military Sites, 4 Universities, 1 Commercial Site 22 Supporters
- 2022 – 37 Counties, 46 Communities, 6 Universities, 2 Commercial Sites, and 29 Supporters

Missouri's 91 StormReady® Designated communities are presented in **Figure 7.24**.

Figure 7.24. Missouri's StormReady Designations



Source: National Weather Service StormReady® Program, http://www.weather.gov/stormready/mo-sr

Disaster Resistant Community Program

Although the program has ended, the State of Missouri's Disaster Resistant Community program, in conjunction with the former FEMA Project Impact program was labeled a great success. Through this initiative, the civic and political leaders of eight communities developed and instituted sound mitigation actions in their respective communities. While only eight communities are formally recognized as

"Disaster Resistant Communities," the Hazard Mitigation Planning initiative promotes similar strategies as communities develop partnerships and a strategy with an ultimate goal of being resistant to the impacts of disasters.

Other Mitigation Projects

The following success stories highlight the potential for future loss reduction and how mitigation projects have been successful in meeting multiple community objectives and effectively leveraging partnerships.

Brush Creek Community Partners

When the Brush Creek Flood Control and Beautification Project was initiated in the 1980s, the decision was made for what is also known as the Federal Project to be constructed between Tracy Avenue and Roanoke Parkway. Since the completion of this phase in 1996, concern about the reach from Roanoke west into Kansas have intensified. The concrete that lines the channel has broken up, the banks are eroding and trees have fallen into the creek. The City of Kansas City, Johnson County, Kansas and the U.S. Army Corps of Engineers have collaborated to examine conditions in the entire 29 square mile watershed in order develop a comprehensive plan to improve flood risk management and water quality while balancing economic, environmental and social benefits. The Bi-State Reach between Roanoke and just into Johnson County is the first of a few specific areas being examined in the study.

MoDNR Dam Safety Program – New Technology Used to Create Dam Inundation Maps

The Missouri DNR's Water Resources Center has developed a procedure for creating dam inundation maps by augmenting field surveys with highly sophisticated imaging and geospatial software and equipment. These systems include high resolution LiDAR elevation data, HEC-RAS software, HEC-GeoRAS, and Digital Elevation Model (DEM) data.

City of Neosho

This city has successfully developed a stormwater utility and has used the funds to create detention basins and improve the aesthetics of the downtown area. These efforts were spurred by participation in an earlier flood buyout program, where the success of mitigation was apparent to the residents and leaders of this community.

Kansas City

Kansas City used its own tax revenue to elevate a low bridge that had been overtopped by a flash flood in 1998 that killed eight people. The Prospect Bridge was elevated in conjunction with creek stabilization and open space improvements using "No Adverse Impact" principles of floodplain management. The very weekend the bridge was dedicated in October 2004, the area experienced heavy rains that could have resulted in flooding if the bridge had not been replaced.

City of Piedmont

This city has an annual creek cleanup, in cooperation with the Department of Conservation and the Natural Resource Conservation Service. This is an example of a true community cooperative effort that involves these agencies as well as local volunteers, including local boy scouts. The cleanup helps reduce flooding by reducing channel clogging debris. The aesthetics of the community are improved, and the environmental benefits include improved habitat for fish.

Hannibal

The Mississippi River has always been a threat to Hannibal; and after eight close calls over three decades, local businessmen, banks, and city government raised the $850,000 local share for a $5.8 million flood wall. The wall, which was constructed between the town and the river, was completed

barely one year before the 1993 flood. The U.S. Corps of Engineers estimated that the wall prevented $14.5 million in damage to downtown Hannibal, more than two times what it cost.

Other areas of Hannibal did not fare so well. Because of the large number of homes that were damaged, the State was quick to initiate a buyout program. The program proved to be successful when, in 1995, another flood struck Hannibal. This time though, no one was forced from their homes, and no homes were ruined. The people and their homes had been moved out of harm's way. In all, 116 homes were purchased in Hannibal through the buyout program, and the land, once a problem, is now an asset, serving a variety of recreational, even revenue generating, purposes.

City of St. Joseph Manufactured Home Park Shelter Ordinance

The City of St. Joseph, Missouri, established an ordinance that requires manufactured home communities to provide storm safe rooms for their residents. All storm safe rooms are required to meet local Americans with Disabilities Act requirements and the design criteria set forth by FEMA 361, Design and Construction Guidance for Community Shelters. For details, contact the City of St. Joseph Building Codes Department.

Kansas City Area Northland Habitat for Humanity Safe room Initiative

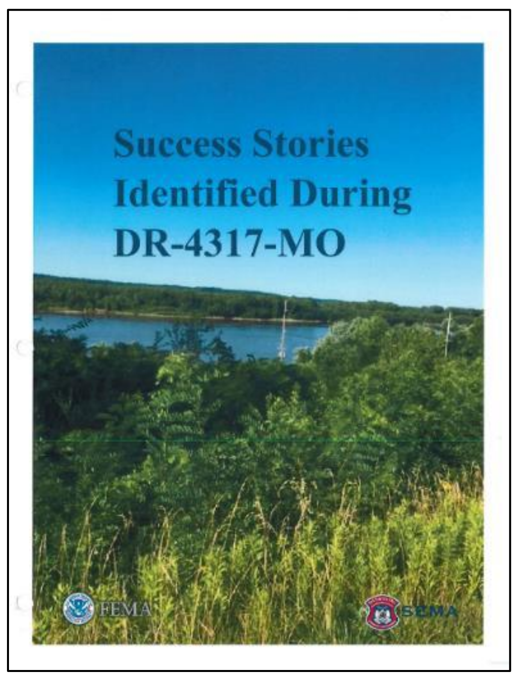
The Habitat for Humanity Northland coordinated the construction of safe rooms in 10 of their homes. All safe rooms were constructed to meet criteria set forth by FEMA 320, *Taking Shelter From the Storm:* Building a Safe room Inside Your House. For details on the Habitat for Humanity safe room projects, contact your local Habitat for Humanity chapter.

Additional Projects

Listed below are more examples of the types of mitigation projects that have been undertaken by communities throughout the State. These projects were cost-effective based on the FEMA benefit-cost analysis module, and they provided a benefit to their communities by decreasing the impact of related disasters.

Success Stories Identified During DR-4317-MO

Mitigation success stories following the June flood event of 2017 are highlighted in the joint FEMA-SEMA publication "Success Stories Identified during DR-4317-MO". Many of these stories such as floodplain management outreach, home buyout, and stream restoration are shared throughout this section.



City of Cassville – Flat Creek stream cleaning and restoration. Sediment accumulation along Flat Creek in Cassville contributed to massive flooding during the August flood event of 2015. The event left homes and businesses flooded, as well as, six ballfields, several trash receptacles and a walking trail. The City utilized funds from their Parks and Stormwater tax to cover the cost to restore the carrying capacity of the stream. In coordination with MoDNR and the USACE, the project included dredging 2,000 feet of upstream creek bed, widening the creek 50 feet, increasing the depth another five feet, and removing small trees and debris.

Following the 2017 flood event (DR-4317), homes and businesses that were damaged in the 2015 flood were not affected, and only two of the six ballfields sustained damage.

City of Richmond—Drop box installation ($2,434), to alleviate flooding caused by stormwater runoff, which exceeded capacity of old drainage system.

Moniteau County—Culvert replacement at four locations ($8,731), to replace and upgrade culverts at four locations.

Platte County—Culvert upgrade at two locations ($20,371), to upgrade culverts where capacity was not sufficient to handle run off from heavy rain events.

Platte County—Sewer upgrade ($11,927), to replace storm sewer in residential area, which was no longer collecting stormwater.

City of Blue Springs—Sewer upgrade ($177,455), to increase capacity of sanitary sewer system in residential area, which would overflow during heavy rain events.

City of Grain Valley—Culvert upgrade ($91,000), to increase capacity of stormwater culvert in residential area, which would overflow during heavy rain events.

City of Grain Valley—Manhole repairs ($32,979), to clean, repair, and seal 48 manholes to prevent infiltration of stormwater into the sanitary sewer system.

City of Lee's Summit—Sewer upgrade ($669,000), to increase capacity of sanitary sewer system in residential area, which would overflow during heavy rain events.

City of Greenwood—Sewer upgrade ($288,233), to replace existing storm sewer system in residential area, which had deteriorated to 10 percent of capacity.

City of Savannah—Sewer improvements ($336,837), to install improved drainage system in commercial and residential area, which overflowed during heavy rain events.

Success Stories – SEMA Promoting Higher Standards with Freeboard Mapping

- Missouri State Emergency Management Agency: Promoting Higher Standards with Freeboard Mapping | FEMA.gov

When the Missouri State Emergency Management Agency maps flood hazards for the state's counties, in addition to federal regulatory Flood Insurance Rate Maps (FIRMs), they create maps showing the extent of flooding that is 1, 2, and 3 feet above the BFE.

Freeboard, or an additional amount of flooding above BFE, is a safety factor used in floodplain management. The Freeboard Maps developed by the state help to show where it rains it can flood. Using the information provided on these maps, communities can mitigate this risk in areas beyond the Special Flood Hazard Area, the mapped area of mandatory flood insurance purchase.

Communities can use the freeboard delineation on the map to determine the level to which a structure's lowest floor should be elevated or floodproofed. By adopting these higher standards, communities can help reduce flood risk to development in, around, and beyond high-risk flood areas.

Success Stories – Using Hazus for Mitigation Planning, 2021

- https://www.fema.gov/sites/default/files/documents/fema_using-hazus-mitigation-planning.pdf

This FEMA guidance document demonstrates how risk assessment results from FEMA's Hazus software can be incorporated into Hazard Mitigation Plans and assist with the development of mitigation actions. It is a goal for the guide to assist users with identifying and understanding the types of reports, tables, maps, and data produced in the Hazus software that can be incorporated into a Hazard Mitigation Plan. The 2018 State Hazard Mitigation Plan was used as an example within this recent publication to illustrate the incorporation of Hazus results.

For the 2023 State Plan Update, the Missouri State Emergency Management Agency (SEMA) used Hazus to model flood vulnerability and estimate flood losses for all 114 counties and the City of St. Louis. Additional hazard data inputs were utilized, as available, to perform Level 2 Hazus analyses. This included the extensive use of the FEMA special flood hazard area data and Risk MAP flood risk datasets.

When evaluating flood risk for the state of Missouri, it was recognized that digital FIRM and Risk MAP datasets were more comprehensive and could assess risk at a more refined level of detail than the floodplains produced entirely by Hazus. While Hazus models are accurate, default analysis is conducted at the 10 sqm scale, whereas the digital FIRM (DFIRM) and Risk MAP data utilizes a 1 sqm scale. Flood analysis was therefore conducted using the latter datasets, in conjunction with available LiDAR (Light Detection and Ranging) data from the Missouri Spatial Data Information Service (MSDIS) and the U.S. Army Corps of Engineers (USACE). When LiDAR was not entirely available, U.S. Geological Survey (USGS) 10-meter digital elevation models were used to supplement any gaps.

To complete the state's user-generated DFIRM depth grid profile, ArcGIS Model-builder was utilized to create series of models using the DFIRM data and elevation data as inputs. The results are displayed illustrating the depth grid generated by the model, which served as an input for the Hazus flood vulnerability and loss analysis.

7.6. Commitment to a Comprehensive Mitigation Program

Requirement §201.5(b)(4)(i-vi): The enhanced plan must demonstrate that the state is committed to a comprehensive state mitigation program, which might include any of the following:

(i) A commitment to support local mitigation planning by providing workshops and training, state planning grants, or coordinated capability development of local officials, including emergency management and floodplain management certifications.

(ii) A statewide program of hazard mitigation through the development of legislative initiatives, mitigation councils, formation of public/private partnerships, and/or other executive actions that promote hazard mitigation.

(iii) The state provides a portion of the non-federal match for HMGP and/or other mitigation projects.

(iv) To the extent allowed by state law, the state requires or encourages local governments to use a current version of a nationally applicable model building code or standard that addresses natural hazards as a basis for design and construction of state sponsored mitigation projects.

(v) A comprehensive, multiyear plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post-disaster response and recovery operations.

(vi) A comprehensive description of how the state integrates mitigation into its post-disaster recovery operations.

Throughout the 2023 plan SEMA and State mitigation planning partners have documented their commitment to a comprehensive mitigation program. The State's desire is for this plan to be a resource to other planning partners.

Support for Local Mitigation Planning

- SEMA has demonstrated its commitment to support local mitigation planning and capability development of local officials throughout this 2023 Plan Update including the successful deployment of the Local Mitigation Plan Outline. Workshops and training are provided for local officials for floodplain management certification, local mitigation planning, hazard mitigation grants, and benefit cost-analysis. The Missouri Certified Emergency Manager Program (MoCEM) is sponsored and administered by the Missouri Emergency Preparedness Association (MEPA) with cooperation and support of the State Emergency Management Agency (SEMA). Certified Floodplain Manger (CFM) training is also supported by SEMA with trainings offered three times each year, as well as, administration of the exam.
    - See also **Sections 4.5.1, 7.1.4, 7.2.4, and 7.3.1**

With the 2023 Plan Update, SEMA is pleased to provide online access to all of the risk assessment data and associated mapping for all 115 counties in the State (including the independent City of St. Louis). Through a web-based Missouri Hazard Mitigation Viewer, local planners or other interested parties can obtain all State Plan datasets. This effort removes a barrier for local mitigation planners to performing all the needed local risk assessments by providing the data developed during the 2023 State Plan Update. Functionality will combine all data layers developed or provided by SEMA planners and partners (State and Local) into one central location. The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2023 State Plan for easy reference, search and query capabilities, zoom levels to county level data and capable of downloadable

PDF format maps. **Figure 7.25** and **Figure 7.26** present the Missouri Hazard Mitigation Viewer's default page and an example of the maps from the 2023 Plan, respectively. The URL is https://bit.ly/MoHazardMitigationPlanViewer2023.

Figure 7.25. Missouri Hazard Mitigation Viewer

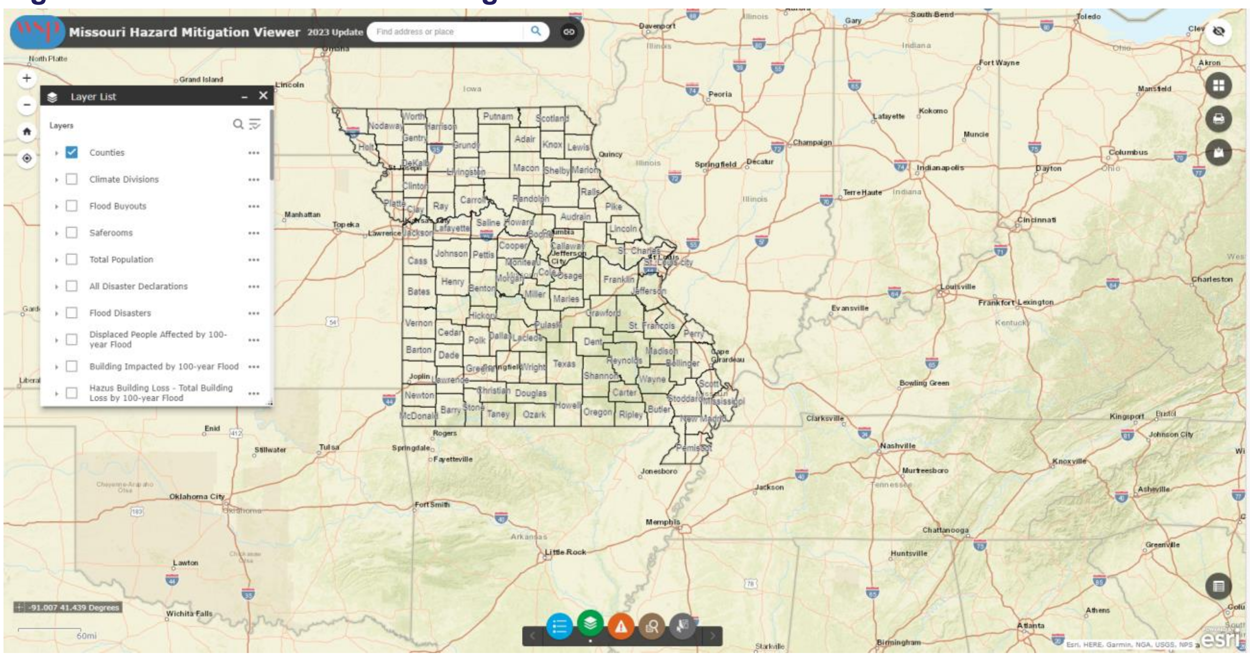
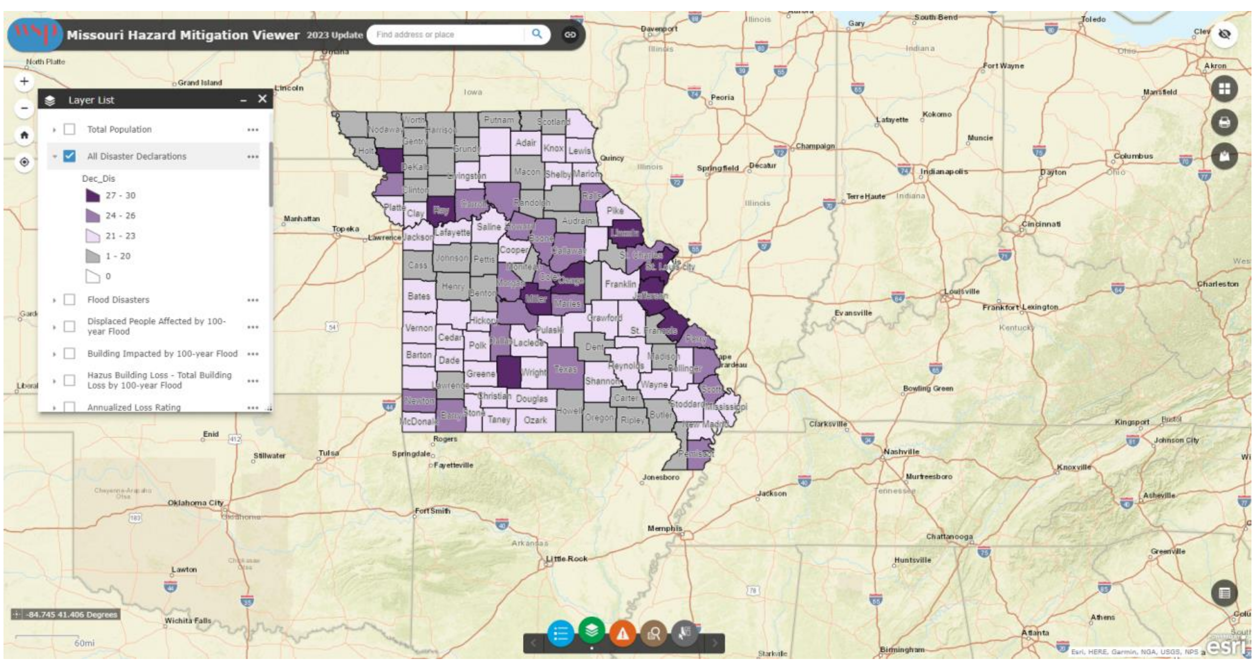


Figure 7.26. Missouri Hazard Mitigation Viewer



Legislative Initiatives, Mitigation Councils, Public/Private Partnerships, Executive Actions

The State of Missouri has demonstrated the use of legislative initiatives, mitigation councils, public/private partnerships, and executive actions in implementing the State's Mitigation Strategy. Below are a few highlights:

- State Statute RSMO 310.200-207 is one example of the State's commitment to mitigation. This statute applies to 47 southeast counties in Missouri that are required to adopt an ordinance requiring new public construction/alteration to comply with seismic design and construction of the BOCA code or UBC.
- Executive Order 97-09 was signed by the lieutenant governor in July 1997 authorizing SEMA to issue floodplain permits for any state-owned or leased development in a special flood hazard area.
- State Risk Management Team (SRMT) is a State Mitigation Council that meets regularly to complete reviews and updates to this Mitigation Plan.
- With the creation of the Flood Recovery Task Force after the 2008 flooding, the Missouri Governor emphasized the need for mitigation planning in the aftermath and recovery from devastating floods.
    - See also **Table 4.2**, Missouri State Statutes and Executive Orders

State Funds for Mitigation

The State of Missouri partially funds the floodplain management budget. In the past, the State of Missouri has provided funding to match mitigation assistance grants. However, this funding has not been available due to budget constraints for approximately 8 years.

Building Design and Construction

For State-sponsored mitigation projects, SEMA requires sub-applicants to adhere to all applicable building code requirements. In addition, for safe room construction projects, SEMA requires adherence to FEMA's Design and Construction Guidance. As indicated previously, all public buildings constructed in the 47 southeastern counties designated as earthquake-prone are required to be constructed in accordance with seismic design and construction.

- See also **Sections 4.2.1, 4.2.4, and 7.2.3**

Mitigation of Risks to Post-Disaster Response and Recovery Operations

Essential facilities, and the associated services and functions, are the most significant components in the protection of the health, safety, and well-being of Missouri and our communities at risk. Essential facilities are those facilities that should be functional after a hazard event and are necessary for post disaster response and recovery operations. To prevent interruptions in essential services, it was important for SEMA to (1) identify essential facilities for response and recovery; (2) identify potential mitigation measures to reduce the vulnerabilities of the essential facilities including utilities, essential systems, and essential equipment; and (3) identify potential funding sources. This process, as outlined below, will be completed within the next 5-years.

Step 1: Identification of Post-Disaster Response and Recovery Facilities

Facilities identified by the Missouri State Emergency Management Agency (SEMA) as essential facilities for response and recovery at the local level include schools, as potential shelters, fire departments and medical facilities.

These essential facilities were first identified through FEMA's HAZUS-multi hazard risk assessment tool and then compared to the 2016 HSIP data to create a complete and updated list. It was determined that the HSIP data was more complete and comprehensive than the default data in HAZUS.

Essential facility subtypes and counts identified within the earthquake study region include:

- Fire Departments - 521
- Educational Facilities – 2,079
  - College/University - 79
  - Private - 567
  - Public – 1,423
  - Supplemental College - 10
- Medical – 386
  - Medical Hospital - 69
  - Nursing Homes - 276
  - Urgent Care – 41

Detailed information on the earthquake analysis and specific facility names are provided in **Section 3.3.4**, **Section 3.5**, and **Appendix C** within the *Missouri Earthquake Risk Assessment Enhancements: Essential Facilities Analysis* Report. **Figure 7.27, Figure 7.28**, and **Figure 7.29** present the location of fire departments, education facilities, and medical facilities within areas of probable earthquake damage. These maps, along with specific facility information for those facilities with a greater than 50-percent complete damage probability, are available within **Appendix C** and on the Missouri Hazard Mitigation Viewer.

Figure 7.27. Fire Departments within Areas of Probably Earthquake Damage

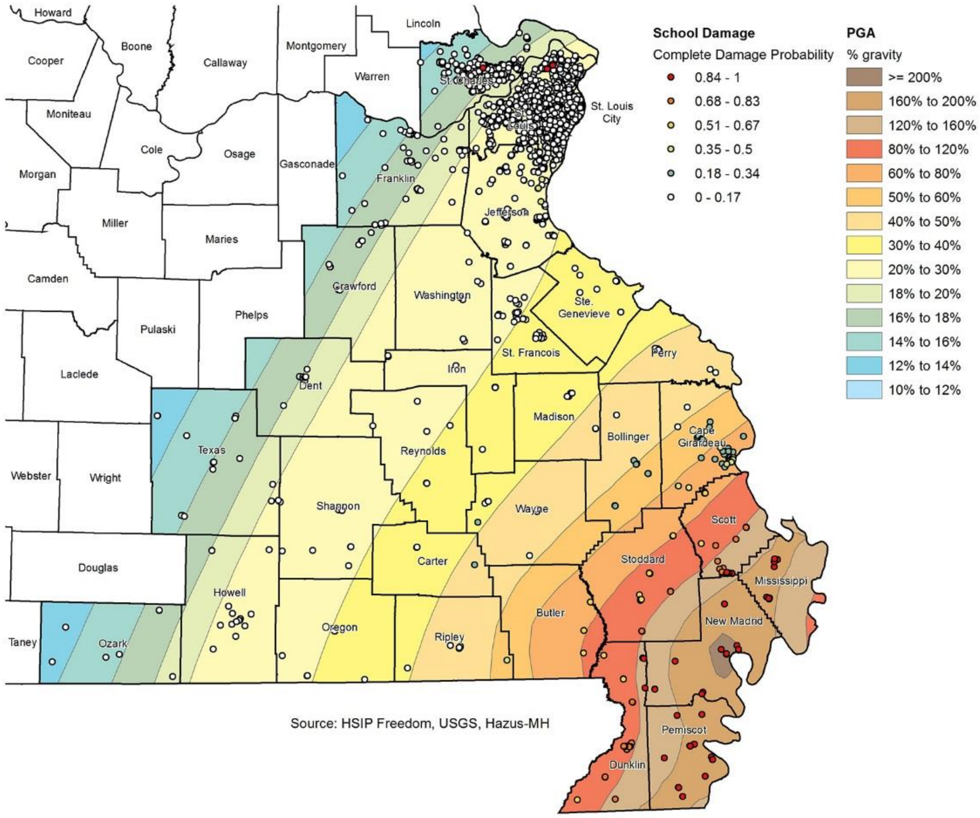
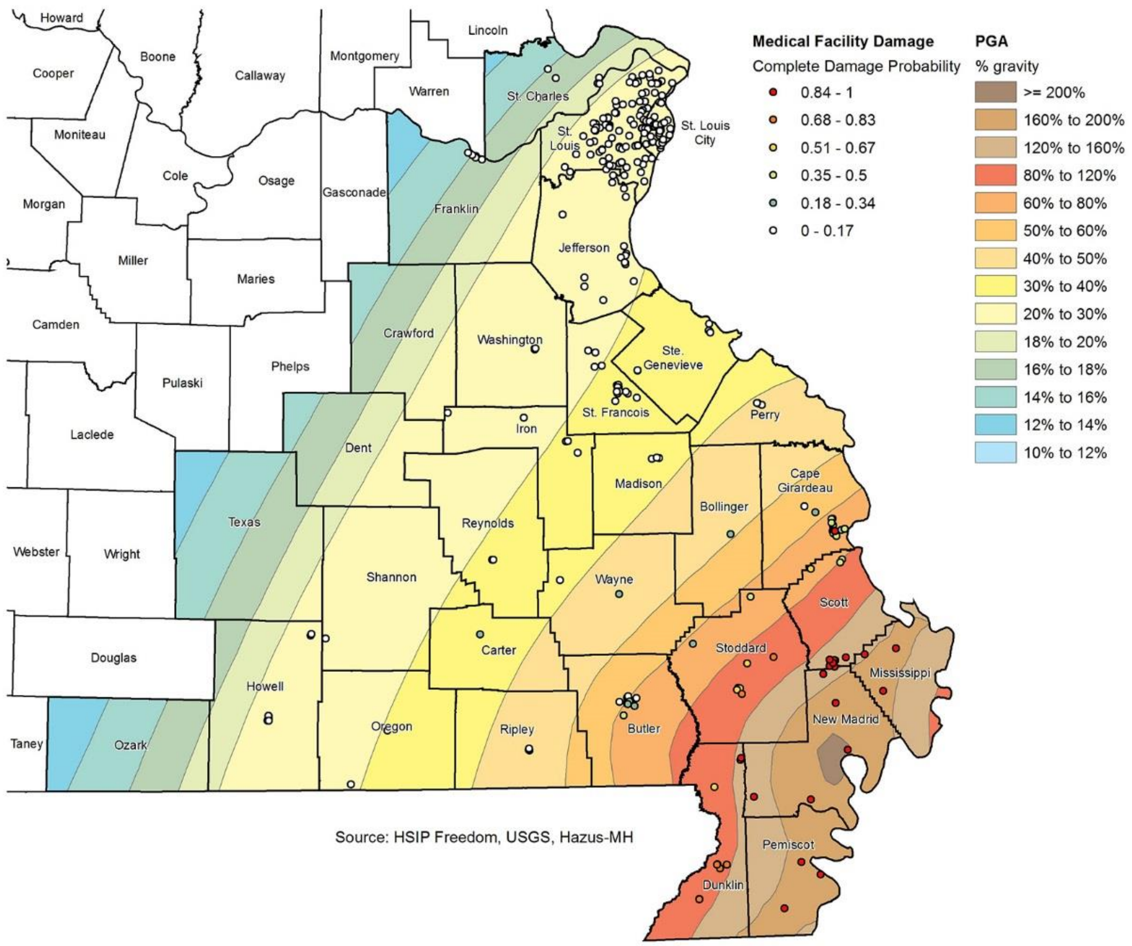


Figure 7.28. Educational Facilties within Areas of Probably Earthquake Damage

Figure 7.29. Medical Facilities within Areas of Probably Earthquake Damage



For the flood hazard, essential facility subtypes and counts within the identified special flood hazard area include:

Fire Departments - 47

Education Facilities – 46

- College/University - 6
- Private - 5
- Public – 35

Medical – 12

- Medical Hospital - 1
- Public Health Department - 7
- Urgent Care – 1

Detailed information on the flood analysis is provided in **Section 3.3.1** and **Section 3.5**. **Figure 7.30**, **Figure 7.31** and **Figure 7.32** present the location of fire departments, education facilities, and medical facilities within the special flood hazard areas. These maps, along with specific facility information, are available within **Appendix C** and on the Missouri Hazard Mitigation Viewer.

Figure 7.30. Fire Departments within the Special Flood Hazard Area

Figure 7.31. Educational Facilities within the Special Flood Hazard Area

Figure 7.32. Medical Facilities within the Special Flood Hazard Area

Step 2 - Identification of Mitigation Measures

For critical facilities identified within the earthquake study region, mitigation measures will be identified over the next five years through the following recommended actions:

1. **Support Local Jurisdictions in Conducting Rapid Visual Screening of Buildings for Potential Seismic Hazards using procedures specified in ATC 21 (FEMA 154)**
   Rapid Visual Screening of Building for Potential Seismic Hazards (RVS) is a pre-disaster procedure that can be implemented quickly and inexpensively to develop a list of potentially hazardous buildings without the cost of a detailed seismic analysis of individual buildings. The fire, medical, and education facilities identified in the enhanced earthquake analysis could be targeted for RVS to identify buildings that may warrant further detailed seismic analysis.

   a. Continue to hold and/or expand training workshops for Rapid Visual Screening of Buildings for Potential Seismic Hazards & Rapid Observation of Vulnerability & Estimation of Risk (ROVER)

2. **Support Local Jurisdictions in Conducting Detailed Seismic Safety Inspections of High Risk Facilities**
   Fire, medical, and education facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential.

   Specific Fire Department assessment

   Fire department facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include assessment of engine bay doors that might be compromised.

   Specific Medical care facilities assessment

   Medical care facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include non-structural seismic safety retrofits such as bracing or securing sensitive medical equipment and reduction of toppling hazards such as shelves and light fixtures that can cause injury and reduce facility functionality.

   Specific Education Facilities assessment

   Education Facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include non-structural seismic safety retrofits such as bracing bookshelves and reduction of other toppling hazards that can cause injury and reduce facility functionality. Facilities designated as potential shelters should be given priority for detailed assessments.

3. **Expand current process for evaluation and prioritization of mitigation actions (see Section 7.2.1) to incorporate and score mitigation projects identified through the Detailed Seismic Safety Inspections.**

4. **Hold Training on ATC 20 Post Earthquake Safety Evaluation of Buildings**
   Following an earthquake disaster there is an immediate need for damage inspections throughout the affected areas. People need to be kept from using unsafe buildings, and safe shelter must be provided for those left homeless. It is essential that qualified building inspectors quickly identify structures that are safe for re-entry and those that must be avoided. Regular building inspection officials may become overloaded instantly and require additional help. Under such emergency

conditions, qualified volunteer inspectors, including architects, engineers, and building inspectors are needed from unaffected regions and certain other qualified design and construction professionals can provide help with the post-earthquake safety evaluations. These volunteers will typically be activated through a pre-existing agreement with state and local emergency management officials. Training using the procedures outlined in ATC 20 should be implemented to bolster this capacity. Attendees of this course would receive inspector qualification training, experience to become a team member for inspecting earthquake damaged buildings, and a field manual to guide their future work.

5. **Encourage Local Jurisdictions to Use Results to plan for post-earthquake shelter planning and preparedness**
   Post-earthquake shelter planning should look at alternate facilities and consider options for relocating people out of the hardest hit areas.

For critical facilities identified within the special flood hazard areas, mitigation measures will be identified over the next five years through the following recommended actions:

1. **Support Local Jurisdictions in Conducting Site Specific Flood Vulnerability Assessments of Buildings for Potential Flood Hazard**
   Identification of specific vulnerabilities at a particular critical facility to flooding may be accomplished by reviewing the facility siting conditions; past flooding issues; location of critical utilities, essential systems, and essential equipment; and emergency management plans.
   a. Develop training workshops for conducting site-specific Flood Vulnerability Assessments
   b. Determine if evacuation plans are in place for critical facilities with vulnerable populations.

2. **Support Local Jurisdictions in developing detailed mitigation projects based upon site specific flood vulnerability assessment. Mitigation projects may include the following:**
   a. <u>Elevate</u> major components of essential systems and equipment that are located below the base flood elevation (BFE).
   b. <u>Dry floodproof</u> around individual pieces of equipment or areas that contain essential equipment to prevent floodwaters from coming into contact with critical equipment.
   c. Install <u>back-up generators</u> for pumping and lift stations in sanitary sewer systems along with other measures (e.g., alarms, meters, remote controls, and switchgear upgrades).
   d. Identify alternate methods for supply critical services to support <u>redundancy</u>.
   e. Install/upgrade stormwater pumping stations.
   f. Install flood telemetry systems in sewage lift stations.
   g. Install earthen dikes around flood-threatened critical facilities.
   h. <u>Anchoring</u> of hazardous materials and/or buoyant materials containers.

   Continue to hold training workshops for "How to Identify Mitigation Actions Using Flood Risk Data and Products". The User Guide for the workshop, see **Appendix B**, presents the process for development of mitigation actions for protection of essential services using Flood Risk Data.

3. **Review existing local hazard mitigation plans with mitigation actions which address emergency services or actions that protect people and property during and immediately after a disaster or hazard event to identify potential projects addressing response and recovery facilities.**

4. **Expand current process for evaluation and prioritization of mitigation actions (see Section 7.2.1) to incorporate and score mitigation projects identified through the Detailed Seismic Safety Inspections.**

Step 3 - Identification of Funding Sources

Funding sources for training workshops include:

- National Earthquake Hazards Reduction Program (NEHRP) Earthquake State Assistance Program
- National Earthquake Technical Assistance Program (NETAP)
- Emergency Management Performance Grants Program (EMPG)
- FEMA Community Engagement and Risk Communication (CERC) program

Additional sources of federal and state funding and technical resources are presented in **Appendix D**.

Step 4 - Next Steps

1. Review current training schedule and identify opportunities for future training workshops for earthquake mitigation - Rapid Visual Screening of Buildings for Potential Seismic Hazards & Rapid Observation of Vulnerability & Estimation of Risk (ROVER).
2. Begin process to develop training workshop for conducting site-specific Flood Vulnerability Assessments.
3. Coordinate with SRMT to expand current process for evaluation and prioritization of mitigation actions to incorporate and score mitigation projects which address critical facilities.
4. Encourage local jurisdictions to incorporate mitigation measures identified through the detailed vulnerability assessments into the local hazard mitigation plans and long-term recovery plans.
5. Expand critical facilities to include police stations; emergency operations centers; communication and data centers; essential government buildings; and other critical facilities and their contents, machinery, and equipment therein, that serve the community or affect the safety, health, or welfare of the surrounding population.
    - See also **Sections 4.2.1, 4.2.3, and 4.2.5**.

Integration of Mitigation into Post-Disaster Recovery

FEMA's Public Assistance (PA) Program provides assistance to the State of Missouri, local governments, and certain types of private nonprofit (PNP) organizations so that our communities can quickly respond to and recover from declared disasters or emergencies. Through the PA Program, FEMA provides supplemental Federal disaster grant assistance for debris removal, emergency protective measures, and the restoration of disaster-damaged, publicly owned facilities and the facilities of certain PNP organizations. The PA Program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures.

In review of the PA Program implementation in Missouri, obligated federal funding for PA projects resulting from declared disasters between the years 2000 and 2021 were identified. This corresponds to disaster declarations DR-1328 through DR-4612.

Disaster Declarations DR-1328 through DR-4612

PA projects fall into two categories: emergency work (A – debris removal; B – emergency protective measures) and permanent work (C – roads/bridges; D – water control facilities; E – buildings/equipment; F – utilities; and G – parks, recreational, and other facilities). The top ten counties for the total number of Public Assistance projects includes: St. Louis, Texas, Miller, Holt, Sullivan, Barry, Jasper, Ray, Webster, and Carroll counties. **Table 7.21** presents the total number of PA projects by county by PA project type. Open projects still under pre-obligation processing are not represented.

As previously noted, hazard mitigation measures may be integrated into the permanent restoration of damaged facilities (PA project types C, D, E, F, and G) to protect the facilities from future damage. Permanent work to restore roads and bridges is the most frequent project type. The top ten counties for the total number of PA permanent work projects includes: Texas, Miller, Sullivan, Webster, Barry, Harrison, Shannon, Putnam, Dade, and Holt.

Table 7.21. Missouri Public Assistance Project Summary, DR-1253 through DR-4612

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Adair	209	8	22	128	2	13	30	6
Andrew	75	13	23	38		1		
Atchison	241	49	75	70	30	4	12	1
Audrain	81	4	9	54	4	3	5	2
Barry	368	56	39	249		7	9	8
Barton	125	9	27	81			7	1
Bates	101	10	32	45	1	2	8	3
Benton	41	6	20	12		2		1
Bollinger	128	15	10	88		8	3	4
Boone	165	12	91	18		36	4	4
Buchanan	161	28	70	25	3	7	6	22
Butler	225	21	58	123	1	6	16	

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Caldwell	135	4	21	108			2	
Callaway	90	11	34	22		9	6	8
Camden	139	13	31	81		5	5	4
Cape Girardeau	257	50	76	66	18	21	11	15
Carroll	312	40	75	169	11	4	13	
Carter	139	9	20	96		10	2	2
Cass	122	32	43	32	1	5	8	1
Cedar	187	41	37	82	1	19	4	3
Chariton	225	26	46	140	3		6	4
Christian	164	27	46	70		5	11	5
Clark	97	11	26	57	1	1		1
Clay	71	21	23	11		8	4	4
Clinton	109	14	18	66		3	4	4
Cole	149	38	76	8		20	3	4
Cooper	38	6	21	8	2			1
Crawford	92	10	9	65	1		6	1
Dade	282	29	20	224		4	2	3
Dallas	186	18	30	128		7	1	2
Daviess	195	3	1	177		3	11	
DeKalb	59	4	9	46				
Dent	57	8	5	41		1	1	1
Douglas	237	8	7	217		2	3	
Dunklin	178	32	49	58	2	15	15	7
Franklin	230	25	42	104	6	12	29	12
Gasconade	57	7	16	24		2	3	5
Gentry	91	8	7	71		1	4	
Greene	209	50	103	22		17	12	5
Grundy	232	9	8	199	2	5	8	1
Harrison	283	5	5	251	1		19	2
Henry	89	6	45	32		3	3	
Hickory	40	5	19	14		2		
Holt	397	68	97	153	32	19	26	2
Howard	143	17	23	78	3	9	6	7
Howell	205	21	26	111	3	15	20	9
Iron	96	9	16	60		1	5	5

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Jackson	245	95	95	11	1	24	10	9
Jasper	368	81	159	18		55	16	39
Jefferson	224	41	80	34	2	22	20	25
Johnson	75	18	31	17		7	1	1
Knox	67	3	3	57		2	1	1
Laclede	201	13	33	137		5	8	5
Lafayette	232	47	50	116	1	7	4	7
Lawrence	251	75	46	96		20	9	5
Lewis	168	22	40	82	2	6	9	7
Lincoln	250	43	112	49	8	19	14	5
Linn	171	6	22	125	2	4	10	2
Livingston	197	3	27	145	1	5	15	1
Macon	105	11	21	63		1	8	1
Madison	118	15	22	64	1	5	9	2
Maries	100	9	16	72		2	1	
Marion	176	23	53	89	1	3	3	4
McDonald	195	20	46	75		14	23	17
Mercer	165	4	1	155			4	1
Miller	411	26	30	337		9	6	3
Mississippi	204	34	40	94	9	17	8	2
Moniteau	21	5	10	4		1	1	
Monroe	90	10	20	45	1	5	8	1
Montgomery	52	11	28	10		3		
Morgan	62	10	24	23		2	3	
New Madrid	269	32	62	117	3	25	19	11
Newton	201	44	60	65		17	5	10
Nodaway	247	33	21	184			9	
Oregon	121	13	14	78		5	6	5
Osage	64	7	20	35		1		1
Ozark	223	11	10	197		2	2	1
Pemiscot	213	24	48	62		41	21	17
Perry	74	11	38	15	1	5	2	2
Pettis	64	7	30	12		13		2
Phelps	148	14	16	109		3	5	1
Pike	188	35	39	86	4	10	10	4

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Platte	162	30	51	34	7	9	12	19
Polk	157	23	47	68		11	4	4
Pulaski	247	27	44	135		12	19	10
Putnam	263	6	16	217	1	4	18	1
Ralls	95	3	10	75		4	3	
Randolph	89	12	30	33	1	3	7	3
Ray	324	41	91	172	3	7	6	4
Reynolds	230	16	17	183		4	8	2
Ripley	88	12	18	48		5	1	4
Saline	125	19	48	47	4	4	3	
Schuyler	41	3	2	25			10	1
Scotland	97	4	3	79		2	9	
Scott	265	59	78	89		20	8	11
Shannon	293	16	12	226	2	8	11	18
Shelby	143	10	16	97	1	8	11	
St. Charles	155	36	73	13	1	9	7	16
St. Clair	49	5	21	17			3	3
St. Francois	67	12	25	12		2	10	6
St. Louis	601	238	287	17		19	8	32
St. Louis (city)	156	20	117	2	1	6	7	3
Ste. Genevieve	119	24	48	40	2	3	1	1
Stoddard	238	56	54	120		4	2	2
Stone	140	18	40	58		3	10	11
Sullivan	377	11	21	310	4		29	2
Taney	239	42	67	63		14	24	29
Texas	455	42	22	375	1	3	6	6
Vernon	215	2	32	167	6	4	2	2
Warren	14	4	9			1		
Washington	77	12	20	41			4	
Wayne	173	14	25	111	2	8	11	2
Webster	321	25	19	265	1	6	2	3
Worth	49	4	9	32		1	3	
Wright	113	14	10	82		2	4	1
Total	**19,649**	**2,632**	**4,355**	**10,153**	**202**	**863**	**886**	**558**

Source: FEMA; https://www.fema.gov/openfema-dataset-public-assistance-funded-projects-details-v1

FEMA uses the Project Worksheet (PW) (FEMA Form 90-91) to document details of the project, including a detailed description of the disaster-related damage, dimensions, and the associated scope of work (SOW) and costs. For those projects with a total cost below the established minimum project threshold, as established by FEMA each fiscal year ($125,500 for 2018), the project is termed small and may be developed by the individual applicant and is subject to a validation process by FEMA. Once FEMA obligates a Small Project, FEMA does not adjust the approved amount of an individual Small Project. The federal cost share is also funded in full, based on the cost estimate, at the time of obligation. For those projects with a total cost greater the established minimum project threshold, the project is termed a large project and is funded based on documented actual costs for eligible work.

In Missouri, communities have been funded for over 11,400 small PA projects with an average cost of $19,118 and just over 1,200 large PA projects with an average cost of $360,991. **Table 7.22** presents the number of PA projects, both large and small, per county, and the average project cost. The top ten counties for the total number of large PA projects are Texas, Sullivan, Miller, Harrison, Barry, Putnam, Dade, Shannon, Douglas, and Grundy. The top ten counties for the total number of small PA projects are Webster, Shannon, Texas, Jasper, Holt, Pulaski, Miller, Barry, Phelps, and Camden.

Table 7.23 through **Table 7.27** present a summary of the project types within each category of PA Project. From these summary tables, the following project types are the most common as well as receive the most funding:

- Repair of damaged public buildings (E) – 529 projects for a total of $121,835,019
- Repair of damaged roadways (C) – 6,776 projects for a total of $234,561,033
- Repair of electrical distribution systems (F) – 223 projects for a total of $68,759,208
- Repair of damaged culverts (C) – 1,260 projects for a total of $23,173,479
- Repair of damaged bridges (C) – 675 projects for a total of $35,150,353
- Repair of sanitary sewer systems (F) – 304 projects for a total of $43,746,414
- Repair of damaged low water crossings (C) – 407 projects for a total of $13,594,728
- Repair of water distribution systems (F) – 229 projects for a total of $11,651,616
- Repair of erosion to ditches/channels (C) – 201 projects for a total of $11,251,468
- Repair of damaged levees (D) – 44 projects for a total of $15,414,513

Incorporation of mitigation measures into each of these PA projects is encouraged. Mitigation measures must be cost effective, meeting one of the following criteria: (1) not exceeding 15% of the total eligible repair cost; (2) not exceeding 100% of the total eligible repair cost of a pre-approved mitigation measure, as provided in FEMA Guidance document FP-104-009-2 Public Assistance Program and Policy Guide, Appendix J; or (3) cost effectiveness is demonstrated through an acceptable benefit-cost analysis methodology, as provided in FEMA's BCA software. Assuming SEMA was able to assist the local jurisdictions with incorporation of mitigation measures costing a minimum of 15% of the total project cost of all the PA projects noted above, the total cost for mitigation would be $97,869,400. The federal share, assumed to be 75% of the mitigation cost, would be $73,402,050. This investment of approximately $73.4M dollars would then save the State of Missouri approximately $440M in future disaster costs, based upon a savings of $6 per every $1 spent.

Table 7.22. Missouri Public Assistance Project Summary – Total and Average Costs for PA C-G, DR-1253 through DR-4612

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Adair	179	$5,311,419	11	$231,190	168	$16,478
Andrew	39	$1,545,881	4	$273,857	35	$12,870
Atchison	117	$8,912,409	24	$264,336	93	$27,617
Audrain	68	$982,359	1	$122,461	67	$12,834
Barry	273	$13,995,961	29	$286,974	244	$23,253
Barton	89	$3,864,910	12	$165,743	77	$24,364
Bates	59	$2,557,595	9	$149,711	50	$24,204
Benton	15	$1,493,798	3	$427,942	12	$17,498
Bollinger	103	$3,142,948	11	$126,219	92	$19,071
Boone	62	$1,744,585	7	$130,379	55	$15,126
Buchanan	63	$3,018,969	10	$148,760	53	$28,894
Butler	146	$4,663,836	19	$139,328	127	$15,879
Caldwell	110	$3,537,477	3	$181,571	107	$27,970
Callaway	45	$957,545	2	$167,062	43	$14,498
Camden	95	$9,432,494	27	$305,289	68	$17,496
Cape Girardeau	131	$4,997,845	10	$349,959	121	$12,382
Carroll	197	$6,826,943	19	$156,232	178	$21,677
Carter	110	$14,674,769	20	$621,098	90	$25,031
Cass	47	$1,662,575	6	$192,200	41	$12,424
Cedar	109	$5,080,030	12	$229,153	97	$24,023
Chariton	153	$3,376,892	2	$91,270	151	$21,155
Christian	91	$3,976,176	10	$251,948	81	$17,984
Clark	60	$1,308,176	2	$125,297	58	$18,234
Clay	27	$1,754,101	5	$277,841	22	$16,586
Clinton	77	$1,787,254	3	$83,262	74	$20,777
Cole	35	$1,291,011	3	$204,548	32	$21,168
Cooper	11	$169,530			11	$15,412
Crawford	73	$2,048,186	7	$80,049	66	$22,543
Dade	233	$5,814,362	6	$172,042	227	$21,067
Dallas	138	$4,618,950	18	$120,363	120	$20,437
Daviess	191	$5,097,467	5	$336,749	186	$18,353
DeKalb	46	$395,457	1	$93,367	45	$6,713
Dent	44	$1,209,278	1	$48,003	43	$27,006
Douglas	222	$4,382,781	9	$168,625	213	$13,451

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Dunklin	97	$13,332,799	13	$962,214	84	$9,810
Franklin	163	$4,838,589	15	$177,990	148	$14,654
Gasconade	34	$715,789	1	$57,048	33	$19,962
Gentry	76	$2,092,072	2	$295,942	74	$20,273
Greene	56	$36,230,370	15	$2,361,113	41	$19,846
Grundy	215	$4,616,706	6	$171,971	209	$17,153
Harrison	273	$6,375,906	5	$231,297	268	$19,475
Henry	38	$948,495	1	$174,802	37	$20,911
Hickory	16	$402,433	1	$170,907	15	$15,435
Holt	232	$27,310,696	33	$704,254	199	$20,454
Howard	103	$2,992,704	10	$204,360	93	$10,205
Howell	158	$6,427,106	11	$252,011	147	$24,864
Iron	71	$1,964,299	7	$97,981	64	$19,975
Jackson	55	$9,067,472	9	$942,052	46	$12,805
Jasper	128	$90,807,281	34	$2,632,952	94	$13,691
Jefferson	103	$6,254,991	12	$391,573	91	$17,100
Johnson	26	$737,631	1	$473,483	25	$10,566
Knox	61	$1,181,329	2	$273,232	59	$10,760
Laclede	155	$7,942,505	20	$224,983	135	$25,503
Lafayette	135	$4,461,944	11	$135,617	124	$23,953
Lawrence	130	$8,637,380	24	$284,400	106	$17,092
Lewis	106	$2,914,002	3	$296,298	103	$19,661
Lincoln	95	$4,540,092	10	$268,791	85	$21,790
Linn	143	$4,728,451	5	$369,541	138	$20,875
Livingston	167	$3,249,473	1	$73,841	166	$19,130
Macon	73	$2,770,349	5	$206,271	68	$25,573
Madison	81	$3,131,948	10	$221,702	71	$12,886
Maries	75	$2,176,422	4	$102,660	71	$24,870
Marion	100	$5,173,733	8	$451,279	92	$16,995
McDonald	129	$5,381,772	17	$176,918	112	$21,198
Mercer	160	$3,156,306	5	$134,352	155	$16,029
Miller	355	$13,505,549	31	$253,719	324	$17,408
Mississippi	130	$12,620,935	20	$502,567	110	$23,360
Moniteau	6	$341,068	2	$149,260	4	$10,637
Monroe	60	$2,392,791	3	$621,067	57	$9,291
Montgomery	13	$868,641	3	$223,015	10	$19,959

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Morgan	28	$652,674	1	$72,861	27	$21,475
New Madrid	175	$4,158,582	12	$173,366	163	$12,750
Newton	97	$3,354,730	9	$196,043	88	$18,072
Nodaway	193	$5,372,644	14	$166,746	179	$16,973
Oregon	94	$2,167,533	5	$239,654	89	$10,891
Osage	37	$1,287,306	4	$151,860	33	$20,602
Ozark	202	$9,332,954	16	$406,205	186	$15,235
Pemiscot	141	$14,390,353	16	$817,221	125	$10,519
Perry	25	$367,003			25	$14,680
Pettis	27	$327,547			27	$12,131
Phelps	118	$7,068,219	28	$164,258	90	$27,433
Pike	114	$3,981,045	15	$130,479	99	$20,443
Platte	81	$8,424,698	12	$590,314	69	$19,434
Polk	87	$2,124,116	10	$109,446	77	$13,372
Pulaski	176	$32,561,242	32	$903,196	144	$25,410
Putnam	241	$5,549,989	11	$153,666	230	$16,781
Ralls	82	$2,319,717	3	$177,385	79	$22,627
Randolph	47	$464,613			47	$9,885
Ray	192	$5,234,133	7	$217,902	185	$20,048
Reynolds	197	$7,269,344	18	$173,592	179	$23,155
Ripley	58	$2,461,970	8	$111,107	50	$31,462
Saline	58	$1,756,889	5	$164,495	53	$17,630
Schuyler	36	$790,020	1	$124,823	35	$19,006
Scotland	90	$1,303,443	1	$79,300	89	$13,754
Scott	128	$4,575,562	7	$417,550	121	$13,659
Shannon	265	$9,814,848	49	$116,140	216	$19,092
Shelby	117	$1,747,163	1	$221,202	116	$13,155
St. Charles	46	$2,632,395	11	$182,704	35	$17,790
St. Clair	23	$364,995	1	$142,761	22	$10,102
St. Francois	30	$871,731	4	$157,164	26	$9,349
St. Louis	76	$2,749,898	5	$244,999	71	$21,478
St. Louis (city)	19	$4,418,942	11	$387,752	8	$19,209
Ste. Genevieve	47	$2,299,827	8	$171,157	39	$23,861
Stoddard	128	$2,850,848	6	$133,212	122	$16,816
Stone	82	$2,243,367	10	$67,745	72	$21,749
Sullivan	345	$6,959,443	11	$89,376	334	$17,893

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Taney	130	$4,360,247	13	$157,078	117	$19,814
Texas	391	$15,429,580	40	$136,913	351	$28,356
Vernon	181	$4,513,487	6	$125,354	175	$21,494
Warren	1	$1,000			1	$1,000
Washington	45	$2,252,210	7	$139,601	38	$33,553
Wayne	134	$4,063,189	13	$124,267	121	$20,229
Webster	277	$15,096,289	97	$119,000	180	$19,741
Worth	36	$733,948			36	$20,387
Wright	89	$2,042,908	2	$98,335	87	$21,221
Grand Total	**12,662**	**$652,666,640**	**1,201**	**$360,991 Average**	**11,461**	**$19,118 Average**

Source: FEMA; https://www.fema.gov/openfema-dataset-public-assistance-funded-projects-details-v1

Table 7.23. PA Projects – Category C – Roads and Bridges, DR-1253 through DR-4612

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Repair to Damaged Roadways	6,776	$234,561,033	$35,184,155
Repair to Damaged Culverts	1,260	$23,173,479	$3,476,022
Repair to Damaged Bridges	675	$35,150,353	$5,272,553
Low Water Crossing Repair	407	$13,594,728	$2,039,209
Ditch/Channel Erosion	201	$11,251,468	$1,687,720
Embankment/Shoulder Erosion	145	$4,330,051	$649,508
Street Sign Damage	22	$365,509	$54,826
Sidewalk Damage	18	$140,214	$21,032
Miscellaneous Stormwater System Damage	36	$1,072,561	$160,884
Other Damage	36	$1,066,574	$159,986
Not Defined	577	$24,816,924	$3,722,539
TOTAL	**10,153**	**$349,522,894**	**$52,428,434**

Table 7.24. PA Projects – Category D – Water Control Facilities, DR-1253 through DR-4612

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Channel/Drainage Ditch Repair	55	$2,618,177	$392,727
Pond/Basin/Reservoir Repair	18	$1,700,898	$255,135
Repair to Damaged Culverts	10	$105,306	$15,796
Dam/Embankment Repair	8	$642,805	$96,421
Spillway Repair	7	$71,669	$10,750

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Levee Repair	44	$15,414,513	$2,312,177
Lift/Pump Stations Damage	23	$707,308	$106,096
Repair to Damaged Roadways	3	$29,545	$4,432
Miscellaneous Stormwater System Damage	9	$514,510	$77,177
Harbor Damage	1	$34,154	$5,123
Water Main Damage	1	$26,690	$4,004
Retaining Wall Damage	3	$24,522	$3,678
Public Building Damage	1	$1,000	$150
Other/Not Defined	19	$906,246	$135,937
TOTAL	**202**	**$22,797,343**	**$3,279,836**

Table 7.25. PA Projects – Category E – Public Buildings, DR-1253 through DR-4612

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Repair to Damaged Buildings	529	$121,835,019	$18,275,253
Repair to Damaged Basements	4	$12,999	$1,950
Equipment/Bldg Contents Damage	148	$3,141,910	$471,286
Vehicle Damage	96	$531,156	$79,673
Repair to Damaged Communication Tower/Antenna	18	$102,324	$15,349
Pump Stations/Lift Stations Damage	15	$167,354	$25,103
Wastewater/Sewage Plant Damage	10	$114,052	$17,108
Traffic Lights/Signs/Flagpole Damage	8	$32,793	$4,919
Fencing Damage	6	$38,620	$5,793
Other/Not Defined	29	$4,764,080	$714,612
TOTAL	**863**	**$130,740,307**	**$19,611,046**

Table 7.26. PA Projects – Category F – Public Utilities, DR-1253 through DR-4612

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Electrical Distribution	223	$68,759,208	$10,313,881
Sanitary Sewer Repairs	304	$43,746,414	$6,561,962
Water Distribution	229	$11,651,616	$1,747,742
Stormwater System	24	$930,241	$139,536
Communications	13	$772,510	$115,876
Gas Utility Repairs	10	$231,557	$34,734

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Fence Damage	6	$47,134	$7,070
Repair to Damaged Roadways	4	$117,841	$17,676
Other/Not Defined	73	$4,046,463	$606,969
TOTAL	**886**	**$130,302,985**	**$19,545,448**

Table 7.27. PA Projects – Category G – Recreational or Other, DR-1253 through DR-4612

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Repair to Damaged Park Facilities/Buildings	91	$3,014,132	$452,120
Fencing Damage	61	$618,842	$92,826
Athletic Field Damages	45	$910,492	$136,574
Repair to Damaged Park Grounds/Landscape	31	$4,473,881	$671,082
Parking Lot/Sidewalks Damage	25	$716,395	$107,459
Repair to Damaged Roadways	17	$179,741	$26,961
Stormwater System Repairs	15	$449,852	$67,478
Electrical Repairs	22	$744,555	$111,683
Trail Repair	22	$378,180	$56,727
Pedestrian Bridge Repair	9	$125,538	$18,831
Other/Not Defined	220	$7,487,530	$1,123,130
TOTAL	**558**	**$19,099,139**	**$2,864,871**

Focusing on the most common and most costly project types, the following are recommendations for inclusion of mitigation measures into the PA process:

General

- The top ten counties for the number of PA projects, both total and permanent, as well as the top ten counties for large and small projects are provided. Recommend coordination with these jurisdictions to gain input on lessons learned and advice for other jurisdictions. A panel discussion at an EMA or M*f*SMA conference is a potential action.
- Example computations assumed mitigation measures would cost only 15% of the total project cost. To encourage mitigation measures which are either on the approved list or demonstrate cost effectiveness above 100% of the project cost, include technical staff from a variety of disciplines on the PA Team, as well as, benefit-cost analyst.

Public Buildings

- As noted in the previous section, *Mitigation of Risks to Post-Disaster Response and Recovery Operations,* critical facilities susceptible to earthquake and flooding have been identified.

Conducting detailed vulnerability assessments at the specific sites will identify mitigation measures that could be incorporated either pre-disaster or following a presidential disaster declaration through the PA process.

  - As noted in the previous section, provide training workshops for local jurisdictions to conduct the detailed vulnerability assessments and include identified mitigation measures in their local hazard mitigation plans and long-term recovery plans.

- Flooded basements of public buildings were a common repair need with equipment and contents subsequently severely damaged. Instruction on dry and wet floodproofing of buildings is recommended.
- Staff the PA Team with a structural engineer to assist with identification of structural mitigation measures such as anchoring to foundations, footings, superstructure, and roofing.
- Partner with organizations, such as the Regional Planning Commissions and the Missouri Municipal League, to communicate and educate staff and members about the risk in their communities through workshops and presentations in their jurisdictions and/or organizational meetings such as annual conferences and newsletters.
- Work closely with the Office of Administration (OA) to identify actions measures to remedy and mitigate State Owned Facilities at risk.

Roads and Bridges

- Washed out roadways and erosion of shoulders and embankments were common repair needs. Include geotextile fabric in the repair design.
- For the repair of this type of damage to be eligible, the local jurisdiction must demonstrate that the damage was directly caused by the incident. Original roadway design drawings and/or maintenance records and photographs will assist in demonstration of damage to the roadway and cause.
- Work with MoDOT State Officials to assist in efforts to replace undersized bridges and culverts.
- Work with MoDOT State Officials to assist in efforts to provide signage for Low Water Crossings in areas identified as at risk.

Electrical Distribution Systems

- Damage to electrical systems can be mitigated by moving the equipment outside the hazard area, or above the flood hazard area, and also by creating a redundant system. Creating redundancies will require local emergency planning based on a comprehensive understanding of system capacity. Funding for this type of local emergency planning will assist jurisdictions in identifying needs for a redundant system and prepare the jurisdiction with mitigation measures for future implementation.
- Continued coordination with the Missouri Department of Energy and implementation of the Comprehensive State Energy Plan.
- Working with Utility Service providers to communicate risk and potentially incentivize property owners to raise at-risk equipment through their Rebate, Incentives and Financing programs already in place, similar to ones for installing energy efficient equipment.

Drainage Structures – Culverts, Bridges, Channels, and Ponds/Basins/Reservoirs

- Mitigation actions for drainage structures, including culverts, require a watershed hydrology study to determine downstream impacts and address NFIP regulations.

- Staff the PA Team with water resources engineer or MoDOT Liaison Engineer *(italic)*

- *Staff the PA Team with water resources engineer or MoDOT Liaison Engineer*
- *Coordinate with local jurisdiction to determine if there are any historical drainage complaints within the immediate area*

➢ Design erosion control and bank stabilization techniques, including the incorporation of green infrastructure.
  - *Staff PA Team with water resources engineer or MoDOT Liaison Engineer*

Sanitary Sewer Systems

➢ Similar to the electrical systems, damage to the sanitary sewer can be mitigated by moving the equipment outside the hazard area, or above the flood hazard area, and also by utilizing submersible or watertight equipment. Staff PA Team with wastewater engineer to assist with project identification.

Sanitary Sewer Systems

➢ Similar to the electrical systems, damage to the sanitary sewer can be mitigated by moving the equipment outside

In recognition of the need to integrate and maximize mitigation into Post-Disaster Recovery, SEMA has developed a Notice of Interest database specifically targeting projects for 406 mitigation funding in coordination with local jurisdictions. SEMA is further working collaboratively with FEMA R-VII to maximize mitigation through development of a pilot program to initiate mitigation project identification and inclusion earlier in the Public Assistance process. Efforts to develop this pilot program are currently underway and include preparation of Memorandums of Understanding between SEMA, and FEMA V-II, The Nature Conservancy, and WSP E&IS to address identified needs and activities such as:

➢ Providing technical assistance for identification and design of potential mitigation measures
➢ Performing benefit-cost analysis of proposed mitigation measures
➢ Providing technical assistance for review of environmental and historic preservation requirements
➢ Providing education and outreach to local jurisdiction to understand the PA process and the incorporation of 406 mitigation

SEMA is also working collaboratively with FEMA R-VII through presentations and speaking engagements on maximizing mitigation at the Emergency Management Institute in March 2018 and at the State Hazard Mitigation Officer Workshop in April 2018.

Comprehensive State Mitigation Program

The overall effectiveness of the State's mitigation program is demonstrated in **Section 7.5** Effective Use of Available Mitigation Funding and in **Section 7.3** Program Management Capability.

Missouri has been in the forefront in mitigation nationally, demonstrated by being one of the first States to develop a FEMA approved 'enhanced' State mitigation plan in 2004. In 2004, the plan demonstrated a commitment to address the "data limitation" noted in the risk assessment and hazard analysis and the lack of approved local hazard mitigation plans through the establishment of mitigation action category M1—State and Local Hazard Mitigation Plans. In 2023, there are FEMA-approved local hazard mitigation plans covering the entire state, representing 104 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives.

Demonstration of Missouri's commitment to mitigation is integrated into each section of this plan and represented in this plan as a whole. Some examples of the evidence of the State's commitment to mitigation can be referenced in:

- **Section 2.1.1** *Evolution of the State Hazard Mitigation Plan* and **Section 4.5** *State Capability Assessment* for organizations within the State that have consistently promoted mitigation:
  - Governor's Task Force on Flood Plain Management
  - Long-Term Recovery and Unmet Needs Groups
  - Structural Assessment and Visual Evaluation Coalition
  - Missouri Seismic Safety Commission
  - Regional Planning Commissions/Councils of Government
  - State Hazard Mitigation Planning Team (formerly the Hazard Mitigation Project Coordinating Group)
- **Section 3.3** *Hazard Profiles and Risk Assessment* for a demonstration of additional commitment in vulnerability assessment. Missouri is one of the few states to have completed countywide Hazus flood and earthquake loss estimations for every county in the State and one of few in the nation to incorporate data from the RiskMAP Program's Flood Risk Database deliverables. In 2023, highlights to the risk assessments include:
  - The risk assessments for all counties were updated utilizing the newly released version of Hazus. For counties which have Risk MAP products available, the depth grids for those communities were utilized as part of the Hazus analysis. For counties with no new floodplains available and for which there are no Risk MAP products, depth grids were created utilizing the updated DFIRM data.
  - The MSDIS structure inventory was used to supplement the Hazus building inventory, as the source for numbers and types of at-risk structures. In addition to the MSDIS structures, building footprints derived from LiDAR during the Risk MAP process were included the numbers and types of at-risk structures.
- **Section 4** Comprehensive State Hazard Mitigation Program for an outline of the mitigation objectives identified to raise the level of mitigation commitment:
  - Objective 1.3—Supports the development of sensible enabling legislation, programs, and capabilities of federal, state, and local governments and public-private partnerships engaged in mitigation activities
  - Objective 2.5—Encourages federal, state, and local officials; educational institutions; private associations; and private business entities that provide essential services to incorporate mitigation into other plans
  - Objective 3.2—Strengthens cooperation with SEMA's mitigation partners and helps educate them about mitigating the loss of property
  - Objective 4.2—Considers sustainability issues (ecologically sound, economically viable, socially just, and humane) when developing or reviewing mitigation projects and plans

- Section 5 Coordination of Local Mitigation Planning provides evidence of Missouri's commitment to the local mitigation planning efforts. The summary of problem statements presents the

SEMA's true commitment to a comprehensive State mitigation program may be best demonstrated through the agency's efforts to meet the Emergency Management Accreditation Program (EMAP) standards. Mitigation and state mitigation planning programs are critical elements of the EMAP standard for mitigation. **Section 2.3.3** *Integration with EMAP Standards* documents how the 2019 EMAP mitigation standards are met and interlaced throughout the 2023 Mitigation Plan. Documentation is included within **Appendix C**. The fact that SEMA has worked diligently to meet the EMAP standards and continues to receive reaccreditation is testimony to the importance that SEMA places on mitigation and emergency management, in general. The figure below presents a recent press release from EMAP congratulating Missouri with the high honor of reaccreditation in 2017 (see **Figure 7.33**). The reaccreditation process for 2022/2023 is ongoing.

Figure 7.33. Media Release from EMAP

EMAP
Emergency Management Accreditation Program

Media Release
For immediate release: October 26, 2017
Contact: Nicole Ishmael, emap@emap.org

Highest Honor for Emergency Management Awarded to Ten Programs

Falls Church, VA. – Congratulations to the following Emergency Management Programs that have earned accreditation by the Emergency Management Accreditation Program (EMAP): Michigan State University; Rhode Island; Idaho; Tufts University; Ramsey County, Mn.; Walla Walla District of the United States Army Corps of Engineers; and FEMA Region VI. In addition, Missouri, Mississippi, City of Boston, Ma.; have achieved reaccreditation.

Appendix A - Risk Assessment Data

Table A.1. Population and HAZUS Building Exposure by County (in 1000's)

County	Estimated Population (V2019)	Building Exposure (HAZUS)								Structure Counts						
		Agriculture	Commercial	Education	Government	Industrial	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Adair	25,343	$16,155	$357,872	$112,765	$16,187	$69,447	$51,170	$2,060,507	$2,684,103	17,344	7,066	869	60	163	37	9,149
Andrew	17,712	$30,888	$156,496	$17,668	$9,348	$25,058	$27,692	$1,566,252	$1,833,402	11,879	4,736	475	23	53	70	6,522
Atchison	5,143	$24,839	$121,930	$10,688	$5,550	$15,597	$30,758	$636,045	$845,407	10,738	7,801	269	34	207	17	2,410
Audrain	25,388	$41,347	$394,542	$39,958	$23,580	$161,075	$78,505	$2,063,751	$2,802,758	25,592	15,295	765	40	274	55	9,163
Barry	35,789	$17,600	$437,853	$46,320	$21,490	$474,483	$73,858	$2,627,327	$3,698,931	28,963	13,871	1,473	51	99	118	13,351
Barton	11,754	$34,587	$195,215	$27,883	$9,228	$201,704	$29,881	$999,009	$1,497,507	15,729	9,810	544	16	112	24	5,223
Bates	16,172	$31,999	$191,457	$30,732	$10,744	$42,816	$33,133	$1,435,177	$1,776,058	12,513	7,016	591	57	29	45	4,775
Benton	19,443	$14,580	$167,842	$20,790	$13,418	$42,408	$45,055	$2,196,859	$2,500,952	15,393	2,630	1,978	12	22	30	10,721
Bollinger	12,133	$9,906	$70,724	$14,663	$7,687	$18,932	$10,354	$933,352	$1,065,618	12,018	7,314	121	9	4	3	4,567
Boone	180,463	$92,232	$2,956,934	$549,021	$161,061	$427,448	$277,738	$14,546,907	$19,011,341	58,267	8,630	1,229	381	159	125	47,743
Buchanan	87,364	$45,036	$2,082,618	$124,388	$68,892	$645,064	$200,686	$7,876,586	$11,043,270	40,969	7,307	1,651	132	1,194	188	30,497
Butler	42,478	$45,912	$669,728	$72,417	$39,997	$189,405	$77,122	$3,145,885	$4,240,466	23,870	5,273	1,300	84	325	43	16,845
Caldwell	9,020	$21,295	$92,451	$28,292	$9,452	$14,594	$18,503	$854,100	$1,038,687	13,640	9,912	123	34	9	21	3,541
Callaway	44,743	$34,076	$499,282	$57,935	$18,269	$134,965	$70,680	$3,726,078	$4,541,285	22,893	7,002	420	92	268	130	14,981
Camden	46,305	$10,950	$733,226	$30,561	$26,603	$182,335	$58,852	$7,512,786	$8,555,313	46,570	2,295	16,544	20	240	49	27,422
Cape Girardeau	78,871	$56,934	$1,646,674	$112,167	$53,658	$355,759	$180,552	$6,638,721	$9,044,465	34,872	10,084	841	67	123	11	23,746
Carroll	8,679	$32,448	$144,016	$22,577	$42,475	$71,873	$24,223	$917,441	$1,255,053	13,675	9,280	351	18	90	51	3,885
Carter	5,982	$1,903	$47,537	$9,188	$6,931	$21,886	$12,905	$428,986	$529,336	4,068	1,418	58	25	27	2	2,538
Cass	105,780	$75,203	$877,056	$114,168	$35,187	$285,453	$117,162	$10,616,368	$12,120,597	56,662	18,745	2,026	124	706	128	34,933
Cedar	14,349	$14,099	$178,138	$8,769	$10,772	$65,890	$30,593	$1,029,955	$1,338,216	9,338	5,106	371	53	11	26	3,771
Chariton	7,426	$31,246	$114,106	$29,597	$5,236	$20,651	$19,620	$741,123	$961,579	13,262	8,808	373	11	33	19	4,018
Christian	88,595	$32,786	$667,149	$65,702	$20,574	$280,343	$104,798	$6,471,712	$7,643,064	42,164	8,670	1,413	67	404	130	31,480
Clark	6,797	$14,819	$91,508	$12,200	$7,981	$20,224	$13,619	$589,473	$749,824	10,066	7,162	224	9	59	11	2,601
Clay	249,948	$54,845	$3,945,883	$231,162	$98,450	$1,102,905	$384,395	$24,407,857	$30,225,497	83,419	5,155	3,183	178	698	110	74,095
Clinton	20,387	$19,630	$201,340	$31,947	$9,443	$58,338	$42,464	$2,095,236	$2,458,398	13,864	4,996	596	39	134	27	8,072
Cole	76,745	$36,633	$1,373,381	$110,599	$1,863,045	$244,643	$292,241	$7,323,942	$11,244,484	28,931	5,305	363	91	239	112	22,821
Cooper	17,709	$36,185	$257,918	$36,736	$13,739	$78,512	$43,188	$1,378,328	$1,844,606	13,024	6,249	527	15	52	65	6,116
Crawford	23,920	$16,660	$268,174	$22,242	$11,605	$153,078	$56,351	$2,037,585	$2,565,695	16,223	4,873	974	15	149	38	10,174
Dade	7,561	$15,037	$74,195	$14,894	$6,056	$38,897	$20,349	$580,344	$749,772	9,624	4,814	271	14	42	21	4,462
Dallas	16,878	$12,458	$124,478	$13,362	$5,607	$37,569	$24,803	$1,148,868	$1,367,145	17,865	9,948	390	12	64	48	7,403
Daviess	8,278	$16,389	$97,297	$30,445	$6,247	$67,238	$13,805	$774,253	$1,005,674	17,736	12,227	965	24	50	40	4,430
DeKalb	12,547	$19,960	$122,033	$9,715	$3,890	$14,495	$14,646	$952,710	$1,137,449	8,340	4,143	371	14	38	67	3,707
Dent	15,573	$8,982	$195,164	$25,942	$9,479	$52,580	$32,770	$1,212,227	$1,537,144	17,221	9,511	700	18	107	49	6,836
Douglas	13,185	$7,928	$94,734	$8,693	$6,356	$26,831	$24,533	$887,943	$1,057,018	13,808	7,489	384	10	52	30	5,843
Dunklin	29,131	$55,735	$580,305	$40,860	$18,318	$55,511	$87,963	$2,200,857	$3,039,549	11,158	2,815	136	26	20	28	8,133
Franklin	103,967	$67,636	$1,455,872	$136,408	$62,508	$956,720	$219,325	$9,685,421	$12,583,890	62,302	18,823	3,049	139	481	120	39,690

County	Estimated Population (V2019)	Building Exposure (HAZUS)								Structure Counts						
		Agriculture	Commercial	Education	Government	Industrial	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Gasconade	14,706	$21,383	$238,598	$40,654	$17,043	$108,484	$41,364	$1,570,579	$2,038,105	12,493	7,000	407	29	60	32	4,965
Gentry	6,571	$20,429	$115,078	$17,440	$11,447	$18,836	$16,874	$534,552	$734,656	8,616	5,082	437	5	53	41	2,998
Greene	293,086	$99,891	$5,433,141	$422,467	$153,176	$1,274,934	$659,779	$24,172,613	$32,216,001	123,403	15,605	7,826	308	651	383	98,630
Grundy	9,850	$21,802	$177,323	$20,450	$10,672	$36,102	$34,599	$933,663	$1,234,611	13,578	8,138	615	21	118	39	4,647
Harrison	8,352	$23,510	$171,662	$18,626	$10,574	$10,052	$29,626	$823,877	$1,087,927	13,676	9,506	323	46	27	20	3,754
Henry	21,824	$42,912	$393,442	$33,817	$26,303	$167,119	$49,016	$1,955,804	$2,668,413	21,520	11,201	879	24	140	64	9,212
Hickory	9,544	$4,174	$55,533	$9,762	$6,498	$11,939	$11,937	$779,250	$879,093	7,533	1,238	686	18	19	37	5,535
Holt	4,403	$27,899	$79,412	$16,341	$6,337	$20,282	$25,862	$486,400	$662,533	9,884	6,628	268	11	96	58	2,823
Howard	10,001	$30,752	$117,248	$23,335	$12,111	$30,063	$33,988	$858,993	$1,106,490	5,649	2,085	244	29	31	11	3,249
Howell	40,117	$28,494	$591,258	$43,921	$25,813	$187,623	$80,403	$2,658,218	$3,615,730	30,415	13,505	1,386	45	474	70	14,935
Iron	10,125	$4,398	$86,092	$6,690	$8,840	$50,866	$39,149	$847,864	$1,043,899	4,947	2,279	135	25	194	27	2,287
Jackson	703,011	$171,759	$16,130,430	$1,221,066	$815,403	$4,403,973	$1,811,052	$71,978,622	$96,532,305	250,658	3,659	13,666	704	3,026	162	229,441
Jasper	121,328	$71,791	$2,069,585	$212,353	$73,811	$651,293	$253,440	$8,826,168	$12,158,441	65,054	13,942	4,217	193	1,958	254	44,490
Jefferson	225,081	$59,855	$2,110,375	$407,003	$84,911	$833,058	$335,303	$20,983,855	$24,814,360	105,667	6,503	5,099	219	536	107	93,203
Johnson	54,062	$41,826	$601,028	$691,222	$35,428	$209,232	$101,199	$4,632,501	$6,312,436	31,227	12,706	959	145	119	1,085	16,213
Knox	3,959	$18,487	$55,161	$7,829	$6,593	$6,887	$8,169	$358,503	$461,629	8,597	6,161	307	4	46	28	2,051
Laclede	35,723	$30,690	$535,023	$36,369	$15,441	$202,906	$74,514	$2,486,537	$3,381,480	24,443	9,964	810	22	274	26	13,347
Lafayette	32,708	$57,599	$515,687	$84,311	$18,161	$120,853	$83,885	$3,318,532	$4,199,028	29,301	14,235	1,348	85	161	44	13,428
Lawrence	38,355	$44,305	$379,880	$48,403	$14,176	$205,389	$88,175	$2,731,460	$3,511,788	30,865	14,507	1,241	51	158	125	14,783
Lewis	9,776	$22,783	$108,875	$14,764	$8,485	$43,853	$27,859	$827,542	$1,054,161	20,578	12,607	635	51	155	38	7,092
Lincoln	59,013	$47,109	$472,879	$32,906	$29,949	$145,219	$74,459	$4,202,987	$5,005,508	33,231	15,516	289	48	26	20	17,332
Linn	11,920	$38,541	$216,263	$35,006	$17,602	$58,314	$38,848	$1,217,603	$1,622,177	14,977	8,066	419	9	77	38	6,368
Livingston	15,227	$21,744	$320,852	$24,641	$16,697	$112,687	$36,046	$1,257,092	$1,789,759	12,422	6,334	321	11	11	43	5,702
Macon	15,117	$32,364	$234,502	$29,725	$27,883	$43,341	$41,379	$1,278,721	$1,687,915	16,318	8,922	726	32	78	48	6,512
Madison	12,088	$6,768	$155,645	$12,748	$5,084	$66,020	$38,104	$932,151	$1,216,520	7,159	1,644	456	47	136	52	4,824
Maries	8,697	$15,922	$64,566	$11,677	$8,538	$52,131	$15,228	$827,822	$995,884	9,706	5,400	349	5	45	15	3,892
Marion	28,530	$30,385	$487,047	$54,933	$24,460	$137,706	$75,961	$2,573,509	$3,384,001	16,799	4,451	1,335	50	218	62	10,683
McDonald	22,837	$13,838	$109,125	$24,309	$8,670	$60,308	$27,413	$1,456,302	$1,699,965	14,795	7,224	322	8	48	11	7,182
Mercer	3,617	$6,693	$39,034	$11,101	$3,848	$4,355	$8,912	$353,023	$426,966	6,818	4,718	142	4	39	16	1,899
Miller	25,619	$22,007	$306,668	$35,150	$9,627	$99,101	$44,883	$2,012,232	$2,529,668	20,087	6,142	2,261	38	102	38	11,506
Mississippi	13,180	$30,812	$132,251	$29,154	$17,282	$20,552	$33,143	$880,856	$1,144,050	7,628	2,528	195	26		29	4,850
Moniteau	16,132	$23,431	$145,578	$27,155	$19,106	$90,098	$30,968	$1,219,881	$1,556,217	12,633	7,484	70	39	14	62	4,964
Monroe	8,644	$18,598	$101,489	$26,639	$7,659	$48,658	$25,917	$773,747	$1,002,707	12,516	7,210	461	19	22	29	4,775
Montgomery	11,551	$30,025	$201,608	$26,199	$16,334	$107,428	$27,418	$1,077,326	$1,486,338	16,650	11,138	205	33	56	22	5,196
Morgan	20,627	$28,654	$311,855	$9,072	$15,398	$80,667	$44,931	$2,483,871	$2,974,448	30,068	10,045	6,631	39	108	8	13,237
New Madrid	17,076	$26,237	$219,403	$42,749	$14,609	$83,830	$31,453	$1,380,093	$1,798,374	14,398	5,946	288	66	193	73	7,832
Newton	58,236	$34,831	$837,849	$136,841	$30,093	$258,607	$119,191	$4,135,228	$5,552,640	35,945	10,796	1,885	105	292	73	22,794

County	Estimated Population (V2019)	Building Exposure (HAZUS)								Structure Counts						
		Agriculture	Commercial	Education	Government	Industrial	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Nodaway	22,092	$39,837	$263,205	$39,618	$17,556	$109,898	$48,473	$2,030,011	$2,548,598	23,183	14,261	618	52	115	75	8,062
Oregon	10,529	$9,401	$102,120	$11,798	$8,957	$14,885	$23,823	$741,599	$912,583	13,375	8,642	500	68	27	20	4,118
Osage	13,615	$20,696	$118,485	$63,398	$12,434	$110,111	$13,824	$1,314,543	$1,653,491	14,148	8,469	350	29	100	24	5,176
Ozark	9,174	$6,362	$71,103	$16,434	$12,863	$27,640	$9,988	$784,771	$929,161	12,398	7,221	483	12	67	22	4,593
Pemiscot	15,805	$19,742	$202,785	$39,200	$18,456	$76,144	$45,848	$1,275,483	$1,677,658	12,568	4,481	352	50	81	65	7,539
Perry	19,136	$43,550	$314,720	$12,995	$8,359	$210,894	$66,580	$1,608,192	$2,265,290	14,796	7,321	230	15	118	19	7,093
Pettis	42,339	$56,302	$839,091	$128,351	$32,364	$286,327	$76,562	$3,136,543	$4,555,540	31,252	14,539	1,728	71	245	100	14,569
Phelps	44,573	$18,990	$795,585	$102,748	$47,323	$147,032	$109,514	$3,765,112	$4,986,304	19,418	3,621	1,049	66	39	70	14,573
Pike	18,302	$27,808	$294,754	$30,186	$17,741	$74,629	$43,224	$1,489,340	$1,977,682	13,573	5,289	796	21	292	72	7,103
Platte	104,418	$37,957	$1,273,137	$102,728	$67,777	$349,976	$141,089	$10,466,475	$12,439,139	34,849	3,909	1,751	71	465	104	28,549
Polk	32,149	$38,037	$340,308	$49,983	$14,036	$72,426	$53,019	$2,146,245	$2,714,054	21,150	8,476	756	61	82	35	11,740
Pulaski	52,607	$12,999	$448,670	$60,670	$51,841	$79,163	$90,899	$4,774,671	$5,518,913	19,605	2,017	538	28	36	5,073	11,913
Putnam	4,696	$15,490	$62,978	$3,542	$5,617	$13,668	$8,297	$445,057	$554,649	8,716	5,933	421	4	72	3	2,283
Ralls	10,309	$20,002	$95,723	$6,130	$7,471	$117,366	$16,085	$965,781	$1,228,558	12,905	6,965	530	12	190	33	5,175
Randolph	24,748	$17,684	$378,387	$50,504	$24,515	$139,617	$54,275	$1,822,773	$2,487,755	16,794	5,221	761	38	214	68	10,492
Ray	23,018	$41,479	$216,650	$39,061	$16,168	$65,198	$43,034	$2,346,022	$2,767,612	16,007	6,600	382	30	68	22	8,905
Reynolds	6,270	$2,685	$51,739	$7,610	$7,146	$30,109	$13,844	$605,806	$718,939	4,482	716	180	23	292	5	3,266
Ripley	13,288	$5,783	$113,338	$25,432	$9,879	$70,407	$24,193	$897,961	$1,146,993	10,129	3,738	226	10	55	18	6,082
Saline	22,761	$32,550	$313,926	$64,601	$22,906	$101,837	$66,471	$1,870,625	$2,472,916	18,058	7,962	555	40	102	35	9,364
Schuyler	4,660	$9,690	$45,490	$2,444	$8,702	$4,633	$8,776	$334,799	$414,534	5,451	3,438	231	18	1	15	1,748
Scotland	4,902	$16,629	$81,770	$8,989	$6,812	$17,571	$7,260	$423,516	$562,547	8,702	6,329	298	11	13	13	2,038
Scott	38,280	$40,986	$690,707	$156,885	$27,144	$217,970	$106,617	$2,899,055	$4,139,364	20,131	5,535	363	34	51	26	14,122
Shannon	8,166	$5,253	$44,557	$8,484	$8,326	$20,234	$9,848	$631,322	$728,024	7,865	3,114	543	53	236	42	3,877
Shelby	5,930	$30,995	$95,249	$16,707	$6,896	$67,796	$33,788	$583,119	$834,550	12,853	9,855	393	15	12	28	2,550
St. Charles	402,022	$96,684	$4,387,498	$484,600	$149,502	$1,164,083	$467,293	$38,187,895	$44,937,555	129,950	5,845	4,972	178	527	89	118,339
St. Clair	9,397	$14,589	$109,520	$19,186	$13,133	$14,695	$19,365	$830,637	$1,021,125	12,306	7,486	649	20	21	25	4,105
St. Francois	67,215	$22,199	$908,068	$83,108	$43,081	$278,488	$168,409	$5,184,866	$6,688,219	27,392	2,377	2,166	53	264	156	22,376
St. Louis	994,205	$340,671	$22,433,658	$2,124,006	$617,489	$7,210,527	$2,131,920	$118,684,043	$153,542,314	490,949	1,761	49,134	1,159	3,228	769	434,898
St. Louis City	300,576	$35,165	$11,055,824	$929,406	$334,015	$3,523,251	$1,329,961	$33,233,154	$50,440,776	104,927	16	7,055	454	2,674	110	94,618
Ste. Genevieve	17,894	$14,266	$236,230	$27,430	$17,638	$157,711	$30,498	$1,804,393	$2,288,166	14,711	5,898	228	4	218	6	8,357
Stoddard	29,025	$48,610	$394,151	$35,750	$22,431	$134,358	$68,848	$2,349,625	$3,053,773	25,156	10,727	473	21	155	19	13,761
Stone	31,952	$11,586	$276,993	$39,610	$10,629	$63,051	$75,916	$3,422,490	$3,900,275	27,851	6,797	3,001	44	132	78	17,799
Sullivan	6,089	$12,168	$70,117	$15,663	$9,836	$41,353	$15,766	$483,499	$648,402	8,018	5,217	157	9	58	7	2,570
Taney	55,928	$15,635	$1,000,115	$36,613	$30,834	$113,386	$129,521	$4,890,391	$6,216,495	26,884	4,202	3,491	59	136	141	18,855
Texas	25,398	$31,404	$263,192	$25,369	$21,690	$97,301	$87,986	$1,857,802	$2,384,744	25,695	15,128	746	87	114	52	9,568
Vernon	20,563	$21,946	$325,053	$107,330	$25,446	$92,005	$34,420	$1,796,154	$2,402,354	16,865	8,970	581	51	34	75	7,154
Warren	35,649	$18,676	$311,138	$28,193	$13,423	$187,018	$45,596	$3,091,829	$3,695,873	20,539	7,419	250	34	27	49	12,760

County	Estimated Population (V2019)	Building Exposure (HAZUS)								Structure Counts						
		Agriculture	Commercial	Education	Government	Industrial	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Washington	24,730	$3,950	$152,229	$27,806	$13,193	$30,131	$53,298	$1,638,874	$1,919,481	16,291	6,331	652	49	81	45	9,133
Wayne	12,873	$4,666	$98,752	$11,884	$7,110	$53,166	$29,987	$1,065,746	$1,271,311	9,020	3,372	128	19	25	4	5,472
Webster	39,592	$24,644	$277,253	$40,386	$10,957	$92,386	$43,303	$2,279,554	$2,768,483	25,782	13,001	659	39	107	84	11,892
Worth	2,013	$7,484	$20,864	$2,576	$5,510	$5,997	$3,052	$240,868	$286,351	2,903	1,606	106	9	7	17	1,158
Wright	18,289	$27,085	$212,631	$29,907	$14,060	$49,959	$53,221	$1,231,478	$1,618,341	19,205	10,925	496	63	175	18	7,528
Total	**6,137,428**	$3,693,951	$105,794,336	$11,335,603	$6,194,39	$32,451,890	$13,268,430	$583,760,067	$756,498,668	16,291	6,331	652	49	81	45	9,133

Population Source: Annual Estimates of the Resident Population for Counties in Missouri: April 1, 2010 to July 1, 2019 (CO-EST2019-ANNRES-29)
Building Source: Hazus
Structure Source: Missouri Spatial Data Information Service (MSDIS) Structures Inventory
*All Values are in thousands of dollars

Table A.2. Missouri Counties Population

County	Population Estimate April 1, 2010	Population Estimate July 1, 2019	Population Change, 2010 to 2019 NUMBER	Population Change, 2010 to 2019 PERCENT
Adair	25,606	25,343	-263	-1.0%
Andrew	17,296	17,712	416	2.4%
Atchison	5,683	5,143	-540	-9.5%
Audrain	25,531	25,388	-143	-0.6%
Barry	35,601	35,789	188	0.5%
Barton	12,396	11,754	-642	-5.2%
Bates	17,047	16,172	-875	-5.1%
Benton	19,057	19,443	386	2.0%
Bollinger	12,358	12,133	-225	-1.8%
Boone	162,652	180,463	17,811	11.0%
Buchanan	89,191	87,364	-1,827	-2.0%
Butler	42,792	42,478	-314	-0.7%
Caldwell	9,418	9,020	-398	-4.2%
Callaway	44,331	44,743	412	0.9%
Camden	44,016	46,305	2,289	5.2%
Cape Girardeau	75,674	78,871	3,197	4.2%
Carroll	9,294	8,679	-615	-6.6%
Carter	6,267	5,982	-285	-4.5%
Cass	99,500	105,780	6,280	6.3%
Cedar	13,982	14,349	367	2.6%
Chariton	7,811	7,426	-385	-4.9%
Christian	77,414	88,595	11,181	14.4%
Clark	7,129	6,797	-332	-4.7%
Clay	221,906	249,948	28,042	12.6%
Clinton	20,743	20,387	-356	-1.7%
Cole	75,975	76,745	770	1.0%
Cooper	17,604	17,709	105	0.6%
Crawford	24,719	23,920	-799	-3.2%
Dade	7,879	7,561	-318	-4.0%
Dallas	16,769	16,878	109	0.7%
Daviess	8,429	8,278	-151	-1.8%
DeKalb	12,884	12,547	-337	-2.6%
Dent	15,692	15,573	-119	-0.8%
Douglas	13,686	13,185	-501	-3.7%
Dunklin	31,957	29,131	-2,826	-8.8%
Franklin	101,468	103,967	2,499	2.5%

County	Population Estimate April 1, 2010	Population Estimate July 1, 2019	Population Change, 2010 to 2019 NUMBER	Population Change, 2010 to 2019 PERCENT
Gasconade	15,206	14,706	-500	-3.3%
Gentry	6,740	6,571	-169	-2.5%
Greene	275,179	293,086	17,907	6.5%
Grundy	10,260	9,850	-410	-4.0%
Harrison	8,961	8,352	-609	-6.8%
Henry	22,291	21,824	-467	-2.1%
Hickory	9,629	9,544	-85	-0.9%
Holt	4,912	4,403	-509	-10.4%
Howard	10,142	10,001	-141	-1.4%
Howell	40,386	40,117	-269	-0.7%
Iron	10,615	10,125	-490	-4.6%
Jackson	674,166	703,011	28,845	4.3%
Jasper	117,391	121,328	3,937	3.4%
Jefferson	218,722	225,081	6,359	2.9%
Johnson	52,565	54,062	1,497	2.8%
Knox	4,131	3,959	-172	-4.2%
Laclede	35,596	35,723	127	0.4%
Lafayette	33,369	32,708	-661	-2.0%
Lawrence	38,647	38,355	-292	-0.8%
Lewis	10,209	9,776	-433	-4.2%
Lincoln	52,536	59,013	6,477	12.3%
Linn	12,773	11,920	-853	-6.7%
Livingston	15,196	15,227	31	0.2%
Macon	15,566	15,117	-449	-2.9%
Madison	12,217	12,088	-129	-1.1%
Maries	9,153	8,697	-456	-5.0%
Marion	28,781	28,530	-251	-0.9%
McDonald	23,083	22,837	-246	-1.1%
Mercer	3,785	3,617	-168	-4.4%
Miller	24,748	25,619	871	3.5%
Mississippi	14,376	13,180	-1,196	-8.3%
Moniteau	15,605	16,132	527	3.4%
Monroe	8,844	8,644	-200	-2.3%
Montgomery	12,224	11,551	-673	-5.5%
Morgan	20,567	20,627	60	0.3%
New Madrid	18,940	17,076	-1,864	-9.8%
Newton	58,118	58,236	118	0.2%
Nodaway	23,373	22,092	-1,281	-5.5%
Oregon	10,881	10,529	-352	-3.2%
Osage	13,909	13,615	-294	-2.1%
Ozark	9,728	9,174	-554	-5.7%

County	Population Estimate April 1, 2010	Population Estimate July 1, 2019	Population Change, 2010 to 2019 NUMBER	Population Change, 2010 to 2019 PERCENT
Pemiscot	18,287	15,805	-2,482	-13.6%
Perry	18,971	19,136	165	0.9%
Pettis	42,214	42,339	125	0.3%
Phelps	45,124	44,573	-551	-1.2%
Pike	18,511	18,302	-209	-1.1%
Platte	89,329	104,418	15,089	16.9%
Polk	31,130	32,149	1,019	3.3%
Pulaski	52,282	52,607	325	0.6%
Putnam	4,979	4,696	-283	-5.7%
Ralls	10,175	10,309	134	1.3%
Randolph	25,418	24,748	-670	-2.6%
Ray	23,516	23,018	-498	-2.1%
Reynolds	6,690	6,270	-420	-6.3%
Ripley	14,106	13,288	-818	-5.8%
Saline	23,370	22,761	-609	-2.6%
Schuyler	4,431	4,660	229	5.2%
Scotland	4,853	4,902	49	1.0%
Scott	39,199	38,280	-919	-2.3%
Shannon	8,435	8,166	-269	-3.2%
Shelby	6,372	5,930	-442	-6.9%
St. Charles	360,495	402,022	41,527	11.5%
St. Clair	9,805	9,397	-408	-4.2%
St. Francois	65,369	67,215	1,846	2.8%
St. Louis	998,985	994,205	-4,780	-0.5%
St. Louis City	319,289	300,576	-18,713	-5.9%
Ste. Genevieve	18,147	17,894	-253	-1.4%
Stoddard	29,968	29,025	-943	-3.1%
Stone	32,208	31,952	-256	-0.8%
Sullivan	6,714	6,089	-625	-9.3%
Taney	51,672	55,928	4,256	8.2%
Texas	26,016	25,398	-618	-2.4%
Vernon	21,163	20,563	-600	-2.8%
Warren	32,539	35,649	3,110	9.6%
Washington	25,201	24,730	-471	-1.9%
Wayne	13,535	12,873	-662	-4.9%
Webster	36,264	39,592	3,328	9.2%
Worth	2,169	2,013	-156	-7.2%
Wright	18,742	18,289	-453	-2.4%
Total	**5,988,950**	**6,137,428**	**148,478**	**2.5%**

Source: U.S. Census Bureau, Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010 to July 1, 2019 (CO-EST2019-CUMCHG-29)

Table A.3. Missouri Population Density Estimates

County	Land Area in Square Miles 2010	Population Estimate April 1, 2010	Population Density 2010	Population Estimate July 1, 2019	Population Density 2019	Population Density Change %
Adair	567.3	25,606	45.1	25,343	44.7	-1.03%
Andrew	432.7	17,296	40.0	17,712	40.9	2.41%
Atchison	547.3	5,683	10.4	5,143	9.4	-9.50%
Audrain	692.2	25,531	36.9	25,388	36.7	-0.56%
Barry	778.3	35,601	45.7	35,789	46.0	0.53%
Barton	591.9	12,396	20.9	11,754	19.9	-5.18%
Bates	836.7	17,047	20.4	16,172	19.3	-5.13%
Benton	704.1	19,057	27.1	19,443	27.6	2.03%
Bollinger	617.9	12,358	20.0	12,133	19.6	-1.82%
Boone	685.4	162,652	237.3	180,463	263.3	10.95%
Buchanan	408.0	89,191	218.6	87,364	214.1	-2.05%
Butler	694.7	42,792	61.6	42,478	61.1	-0.73%
Caldwell	426.4	9,418	22.1	9,020	21.2	-4.23%
Callaway	834.6	44,331	53.1	44,743	53.6	0.93%
Camden	655.9	44,016	67.1	46,305	70.6	5.20%
Cape Girardeau	578.5	75,674	130.8	78,871	136.3	4.22%
Carroll	694.6	9,294	13.4	8,679	12.5	-6.62%
Carter	507.4	6,267	12.4	5,982	11.8	-4.55%
Cass	696.8	99,500	142.8	105,780	151.8	6.31%
Cedar	474.5	13,982	29.5	14,349	30.2	2.62%
Chariton	751.2	7,811	10.4	7,426	9.9	-4.93%
Christian	562.7	77,414	137.6	88,595	157.5	14.44%
Clark	504.7	7,129	14.1	6,797	13.5	-4.66%
Clay	397.3	221,906	558.5	249,948	629.1	12.64%
Clinton	419.0	20,743	49.5	20,387	48.7	-1.72%
Cole	393.8	75,975	193.0	76,745	194.9	1.01%
Cooper	564.8	17,604	31.2	17,709	31.4	0.60%
Crawford	742.5	24,719	33.3	23,920	32.2	-3.23%
Dade	490.0	7,879	16.1	7,561	15.4	-4.04%
Dallas	540.8	16,769	31.0	16,878	31.2	0.65%
Daviess	563.2	8,429	15.0	8,278	14.7	-1.79%
DeKalb	421.4	12,884	30.6	12,547	29.8	-2.62%
Dent	752.8	15,692	20.8	15,573	20.7	-0.76%
Douglas	813.6	13,686	16.8	13,185	16.2	-3.66%
Dunklin	541.1	31,957	59.1	29,131	53.8	-8.84%
Franklin	922.7	101,468	110.0	103,967	112.7	2.46%
Gasconade	517.8	15,206	29.4	14,706	28.4	-3.29%
Gentry	491.4	6,740	13.7	6,571	13.4	-2.51%

County	Land Area in Square Miles 2010	Population Estimate April 1, 2010	Population Density 2010	Population Estimate July 1, 2019	Population Density 2019	Population Density Change %
Greene	675.3	275,179	407.5	293,086	434.0	6.51%
Grundy	435.3	10,260	23.6	9,850	22.6	-4.00%
Harrison	722.5	8,961	12.4	8,352	11.6	-6.80%
Henry	697.0	22,291	32.0	21,824	31.3	-2.10%
Hickory	399.1	9,629	24.1	9,544	23.9	-0.88%
Holt	462.7	4,912	10.6	4,403	9.5	-10.36%
Howard	463.9	10,142	21.9	10,001	21.6	-1.39%
Howell	927.3	40,386	43.6	40,117	43.3	-0.67%
Iron	550.3	10,615	19.3	10,125	18.4	-4.62%
Jackson	604.5	674,166	1,115.3	703,011	1163.0	4.28%
Jasper	638.5	117,391	183.9	121,328	190.0	3.35%
Jefferson	656.6	218,722	333.1	225,081	342.8	2.91%
Johnson	829.3	52,565	63.4	54,062	65.2	2.85%
Knox	504.0	4,131	8.2	3,959	7.9	-4.16%
Laclede	764.7	35,596	46.5	35,723	46.7	0.36%
Lafayette	628.4	33,369	53.1	32,708	52.0	-1.98%
Lawrence	611.7	38,647	63.2	38,355	62.7	-0.76%
Lewis	505.0	10,209	20.2	9,776	19.4	-4.24%
Lincoln	626.6	52,536	83.8	59,013	94.2	12.33%
Linn	615.6	12,773	20.8	11,920	19.4	-6.68%
Livingston	532.3	15,196	28.5	15,227	28.6	0.20%
Macon	801.2	15,566	19.4	15,117	18.9	-2.88%
Madison	494.4	12,217	24.7	12,088	24.5	-1.06%
Maries	527.0	9,153	17.4	8,697	16.5	-4.98%
Marion	436.9	28,781	65.9	28,530	65.3	-0.87%
McDonald	539.5	23,083	42.8	22,837	42.3	-1.07%
Mercer	453.8	3,785	8.3	3,617	8.0	-4.44%
Miller	592.6	24,748	41.8	25,619	43.2	3.52%
Mississippi	411.6	14,376	34.9	13,180	32.0	-8.32%
Moniteau	415.0	15,605	37.6	16,132	38.9	3.38%
Monroe	647.7	8,844	13.7	8,644	13.3	-2.26%
Montgomery	536.3	12,224	22.8	11,551	21.5	-5.51%
Morgan	597.6	20,567	34.4	20,627	34.5	0.29%
New Madrid	674.8	18,940	28.1	17,076	25.3	-9.84%
Newton	624.8	58,118	93.0	58,236	93.2	0.20%
Nodaway	877.0	23,373	26.7	22,092	25.2	-5.48%
Oregon	789.8	10,881	13.8	10,529	13.3	-3.23%
Osage	604.4	13,909	23.0	13,615	22.5	-2.11%
Ozark	745.0	9,728	13.1	9,174	12.3	-5.69%

County	Land Area in Square Miles 2010	Population Estimate April 1, 2010	Population Density 2010	Population Estimate July 1, 2019	Population Density 2019	Population Density Change %
Pemiscot	492.5	18,287	37.1	15,805	32.1	-13.57%
Perry	474.4	18,971	40.0	19,136	40.3	0.87%
Pettis	682.2	42,214	61.9	42,339	62.1	0.30%
Phelps	671.8	45,124	67.2	44,573	66.4	-1.22%
Pike	670.4	18,511	27.6	18,302	27.3	-1.13%
Platte	420.2	89,329	212.6	104,418	248.5	16.89%
Polk	635.5	31,130	49.0	32,149	50.6	3.27%
Pulaski	547.1	52,282	95.6	52,607	96.2	0.62%
Putnam	517.3	4,979	9.6	4,696	9.1	-5.68%
Ralls	469.8	10,175	21.7	10,309	21.9	1.32%
Randolph	482.7	25,418	52.7	24,748	51.3	-2.64%
Ray	568.8	23,516	41.3	23,018	40.5	-2.12%
Reynolds	808.5	6,690	8.3	6,270	7.8	-6.28%
Ripley	629.5	14,106	22.4	13,288	21.1	-5.80%
Saline	755.5	23,370	30.9	22,761	30.1	-2.61%
Schuyler	307.3	4,431	14.4	4,660	15.2	5.17%
Scotland	436.7	4,853	11.1	4,902	11.2	1.01%
Scott	420.0	39,199	93.3	38,280	91.1	-2.34%
Shannon	1003.8	8,435	8.4	8,166	8.1	-3.19%
Shelby	500.9	6,372	12.7	5,930	11.8	-6.94%
St. Charles	560.4	360,495	643.2	402,022	717.3	11.52%
St. Clair	670.0	9,805	14.6	9,397	14.0	-4.16%
St. Francois	451.9	65,369	144.7	67,215	148.7	2.82%
St. Louis	507.8	998,985	1,967.3	994,205	1957.9	-0.48%
St. Louis City	61.9	319,289	5,157.3	300,576	4855.0	-5.86%
Ste. Genevieve	499.2	18,147	36.4	17,894	35.8	-1.39%
Stoddard	823.2	29,968	36.4	29,025	35.3	-3.15%
Stone	464.0	32,208	69.4	31,952	68.9	-0.79%
Sullivan	648.0	6,714	10.4	6,089	9.4	-9.31%
Taney	632.4	51,672	81.7	55,928	88.4	8.24%
Texas	1177.3	26,016	22.1	25,398	21.6	-2.38%
Vernon	826.4	21,163	25.6	20,563	24.9	-2.84%
Warren	428.6	32,539	75.9	35,649	83.2	9.56%
Washington	759.9	25,201	33.2	24,730	32.5	-1.87%
Wayne	759.2	13,535	17.8	12,873	17.0	-4.89%
Webster	592.6	36,264	61.2	39,592	66.8	9.18%
Worth	266.6	2,169	8.1	2,013	7.6	-7.19%
Wright	681.8	18,742	27.5	18,289	26.8	-2.42%
Total	68741.5	5,988,950	87.1	6,137,428	89.3	2.48%

Source: U.S. Census Bureau, 2Cumulative Estimates of Resident Population Change and Rankings for Counties in Missouri: April 1, 2010 to July 1, 2019 (CO-EST2019-CUMCHG-29)

Table A.4. Social Vulnerability to Environmental Hazards, Comparison within the State, 2010-2014

County	SOVI Index Ranking
Adair	Medium
Andrew	Medium Low
Atchison	Medium High
Audrain	Medium High
Barry	Medium
Barton	Medium
Bates	Medium
Benton	Medium High
Bollinger	Medium Low
Boone	Low
Buchanan	Medium
Butler	Medium High
Caldwell	Medium
Callaway	Medium Low
Camden	Medium High
Cape Girardeau	Medium
Carroll	Medium
Carter	Medium High
Cass	Low
Cedar	Medium High
Chariton	Medium High
Christian	Medium Low
Clark	Medium Low
Clay	Medium Low
Clinton	Medium
Cole	Medium Low
Cooper	Medium Low
Crawford	Medium
Dade	Medium
Dallas	Medium
Daviess	Medium
DeKalb	Low
Dent	Medium High
Douglas	Medium
Dunklin	High
Franklin	Medium Low
Gasconade	Medium
Gentry	Medium High

County	SOVI Index Ranking
Greene	Medium
Grundy	Medium High
Harrison	Medium High
Henry	Medium
Hickory	High
Holt	Medium
Howard	Medium Low
Howell	Medium
Iron	Medium High
Jackson	Medium
Jasper	Medium
Jefferson	Low
Johnson	Low
Knox	Medium High
Laclede	Medium
Lafayette	Medium Low
Lawrence	Medium
Lewis	Medium
Lincoln	Low
Linn	Medium High
Livingston	Medium High
Macon	Medium High
Madison	Medium High
Maries	Medium
Marion	Medium High
McDonald	Medium
Mercer	Medium High
Miller	Medium High
Mississippi	Medium High
Moniteau	Medium Low
Monroe	Medium
Montgomery	Medium High
Morgan	Medium High
New Madrid	High
Newton	Medium Low
Nodaway	Medium
Oregon	Medium High
Osage	Low

County	SOVI Index Ranking
Ozark	Medium
Pemiscot	High
Perry	Medium Low
Pettis	Medium
Phelps	Medium Low
Pike	Medium Low
Platte	Low
Polk	Medium
Pulaski	Low
Putnam	Medium
Ralls	Medium Low
Randolph	Medium Low
Ray	Medium Low
Reynolds	Medium High
Ripley	Medium High
Saline	Medium
Schuyler	Medium
Scotland	Medium High
Scott	Medium
Shannon	Medium

County	SOVI Index Ranking
Shelby	Medium
St. Charles	Low
St. Clair	Medium High
St. Francois	Medium Low
St. Louis	Medium Low
St. Louis City	High
Ste. Genevieve	Medium Low
Stoddard	Medium
Stone	Medium High
Sullivan	Medium High
Taney	High
Texas	Medium
Vernon	Medium High
Warren	Medium Low
Washington	Medium
Wayne	Medium High
Webster	Medium Low
Worth	Medium High
Wright	Medium

Table A.5. National Historic Places by County, January 6, 2022

County	Number of National Historic Places
Adair	20
Andrew	3
Atchison	8
Audrain	4
Barry	15
Barton	1
Bates	4
Benton	4
Bollinger	2
Boone	52
Buchanan	64
Butler	25
Caldwell	2
Callaway	20
Camden	9
Cape Girardeau	62
Carroll	6
Carter	30
Cass	7
Cedar	3
Chariton	7
Christian	3
Clark	5
Clay	40
Clinton	1
Cole	54
Cooper	44
Crawford	13
Dade	3
Dallas	1
Daviess	3
DeKalb	3
Dent	8
Douglas	1
Dunklin	8
Franklin	62
Gasconade	10
Gentry	4
Greene	77
Grundy	7
Harrison	2
Henry	8
Hickory	2

County	Number of National Historic Places
Holt	4
Howard	25
Howell	6
Iron	6
Jackson	400
Jasper	38
Jefferson	14
Johnson	22
Knox	2
Laclede	7
Lafayette	29
Lawrence	5
Lewis	12
Lincoln	5
Linn	5
Livingston	4
Macon	9
Madison	5
Maries	1
Marion	40
McDonald	4
Mercer	2
Miller	9
Mississippi	11
Moniteau	11
Monroe	10
Montgomery	9
Morgan	5
New Madrid	10
Newton	13
Nodaway	9
Oregon	3
Osage	9
Ozark	2
Pemiscot	7
Perry	9
Pettis	28
Phelps	11
Pike	21
Platte	16
Polk	4
Pulaski	7
Putnam	1

County	Number of National Historic Places
Ralls	9
Randolph	4
Ray	6
Reynolds	2
Ripley	8
Saline	33
Schuyler	2
Scotland	3
Scott	7
Shannon	16
Shelby	4
St. Charles	39
St. Clair	3
St. Francois	12
St. Louis	647
St. Louis City	2
Ste. Genevieve	6
Stoddard	5
Stone	3
Sullivan	6
Taney	6
Texas	5
Vernon	8
Warren	8
Washington	11
Wayne	3
Webster	3
Worth	1
Wright	5
Total	2424

Source: National Register of Historic Places

Table A.6. Threatened and Endangered Species in Missouri

Status	Scientific Name	Common Name	Group
T	Amblyopsis rosae	Ozark cavefish	Fishes
E	Antrobia culveri	Tumbling Creek cavesnail	Snails
T	Asclepias meadii	Mead's milkweed	Flowering Plants
T	Boltonia decurrens	Decurrent false aster	Flowering Plants
T	Calidris canutus rufa	Red knot	Birds
E	Cambarus aculabrum	Benton County cave crayfish	Crustaceans
E	Corynorhinus (=Plecotus) townsendii ingens	Ozark big-eared bat	Mammals
E	Cottus specus	Grotto Sculpin	Fishes
T	Cryptobranchus alleganiensis alleganiensis	Eastern Hellbender Missouri DPS	Amphibians
E	Cryptobranchus alleganiensis bishopi	Ozark Hellbender	Amphibians
E	Cumberlandia monodonta	Spectaclecase (mussel)	Clams
E	Epioblasma florentina curtisii	Curtis pearlymussel	Clams
E	Epioblasma triquetra	Snuffbox mussel	Clams
T	Etheostoma nianguae	Niangua darter	Fishes
T	Geocarpon minimum	No common name	Flowering Plants
T	Helenium virginicum	Virginia sneezeweed	Flowering Plants
E	Lampsilis abrupta	Pink mucket (pearlymussel)	Clams
E	Lampsilis higginsii	Higgins eye (pearlymussel)	Clams
E	Lampsilis rafinesqueana	Neosho Mucket	Clams
E	Leptodea leptodon	Scaleshell mussel	Clams
E	Lindera melissifolia	Pondberry	Flowering Plants
E	Myotis grisescens	Gray bat	Mammals
T	Myotis septentrionalis	Northern Long-Eared Bat	Mammals
E	Myotis sodalis	Indiana bat	Mammals
T	Nicrophorus americanus	American burying beetle	Insects
E	Notropis topeka (=tristis)	Topeka shiner	Fishes
T	Noturus placidus	Neosho madtom	Fishes
T	Physaria filiformis	Missouri bladderpod	Flowering Plants
T	Platanthera leucophaea	Eastern prairie fringed orchid	Flowering Plants
T	Platanthera praeclara	Western prairie fringed Orchid	Flowering Plants

Statu s	Scientific Name	Common Name	Group
E	Plethobasus cyphyus	Sheepnose Mussel	Clams
E	Potamilus capax	Fat pocketbook	Clams
T	Quadrula cylindrica cylindrica	Rabbitsfoot	Clams
E	Quadrula fragosa	Winged Mapleleaf	Clams
E	Scaphirhynchus albus	Pallid sturgeon	Fishes
E	Somatochlora hineana	Hine's emerald dragonfly	Insects

Source: US Fish and Wildlife Service

Hazard Identification – Weather Patterns

According to Dr. Grant Darkow, Department of Atmospheric Science at the University of Missouri-Columbia, specific recognizable weather patterns are responsible for Missouri's weather, especially those that "*tend to produce extremes in precipitation, resulting in unusually wet or drought conditions, and extremes in temperature, either abnormally warm or cold.*" Darkow explains:

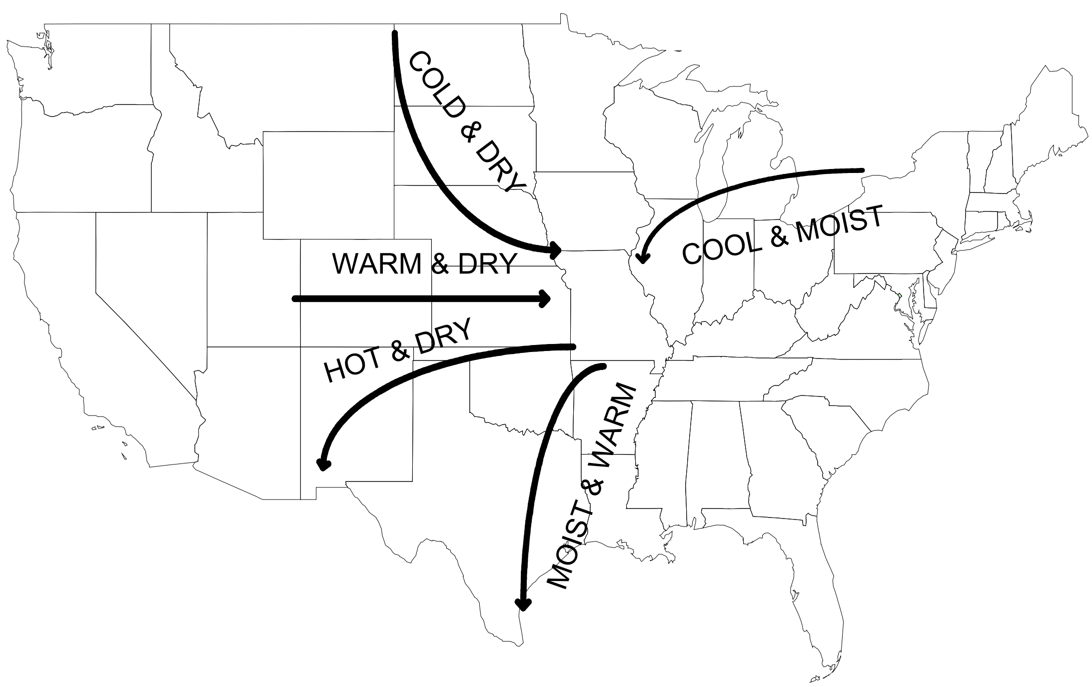
The character of air over Missouri on any particular day or series of days is dominated by the source regions from which it comes. Missouri's midcontinental location makes it subject to air flows from a variety of source regions with markedly different properties.

The state is close enough to the Gulf of Mexico that warm air with high humidity can flow into the state from a southerly direction at almost any time of the year. This warm, moist air is the principal source of spring, summer, and fall precipitation and, occasionally, precipitation in winter as well.

In contrast, air arriving over Missouri from semi-arid to arid regions to the southwest is warm or hot and usually dry as. Air that has moved from west to east over the Rocky Mountains arrives warm and dry, having lost most of its low-level moisture as it climbed the west side of the mountains.

Abnormally cold air in the winter and cold summer air with only very small moisture content arrives over Missouri from the northwest or north, whereas air entering Missouri from the northeast will tend to be cool and moist.

Figure A.1. Source Regions and Atmospheric Characteristics for Air Arriving in Missouri



Darkow goes on to explain:

Normally, the flow from one of the principal source regions will last for two or three days before switching to a different direction and source region. These transitions typically are accompanied by a frontal passage during which the change in wind direction, temperature, and moisture content, or any combination, is concentrated.

In some instances, however, a particular flow pattern may be very persistent or dominant for a period of weeks or even months. These periods can lead to wet, dry, hot, or cold spells, and the extremes associated with these periods. These periods are characterized by particular upper air flow patterns and associated surface weather patterns (see Figure A.2, Figure A.3, Figure A.4, Figure A.5, Figure A.6, and Figure A.7), sourced from the 2012 State Hazard Analysis, Missouri and Kentucky Universities.

Figure A.2. Upper Air Pattern: Results in weather that is Warm or hot and usually dry

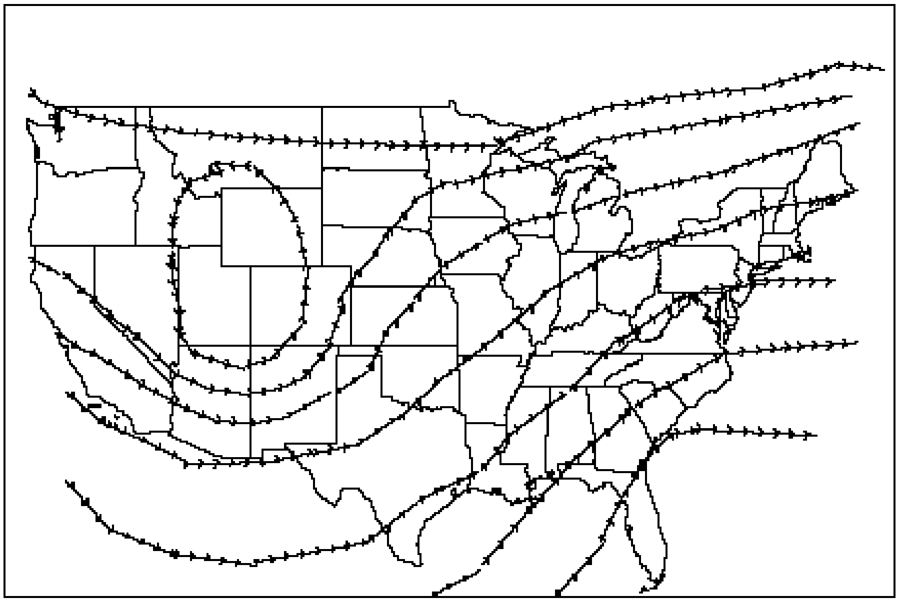


Figure A.3. Surface Air Pattern: Results in weather that is Cool and Moist

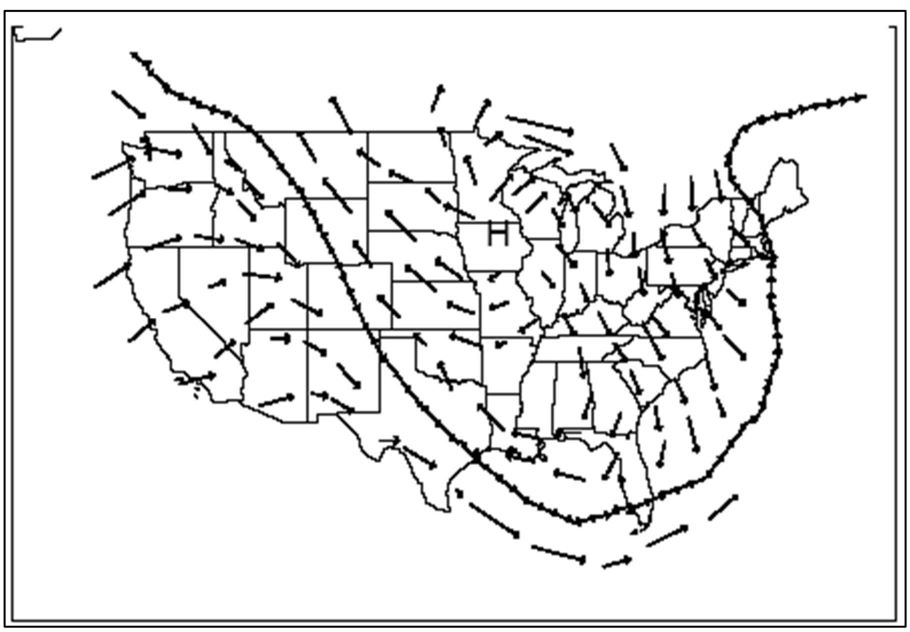


Figure A.4. Upper Air Pattern: Results in weather that is Cold and Dry

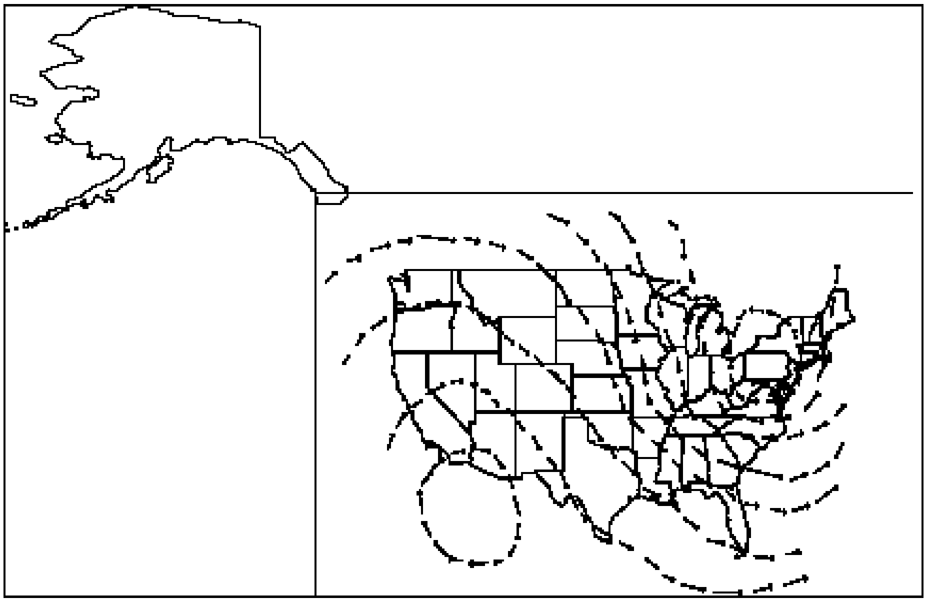


Figure A.5. Surface Air Pattern: Results in weather that is Warm and Moist

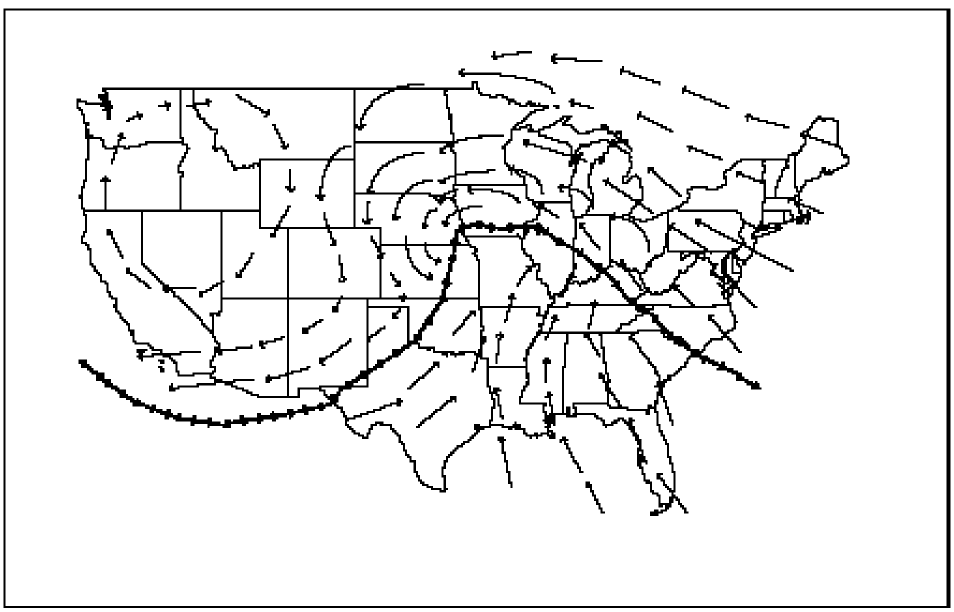


Figure A.6. Upper Air Pattern: Results in weather that is Hot and Dry

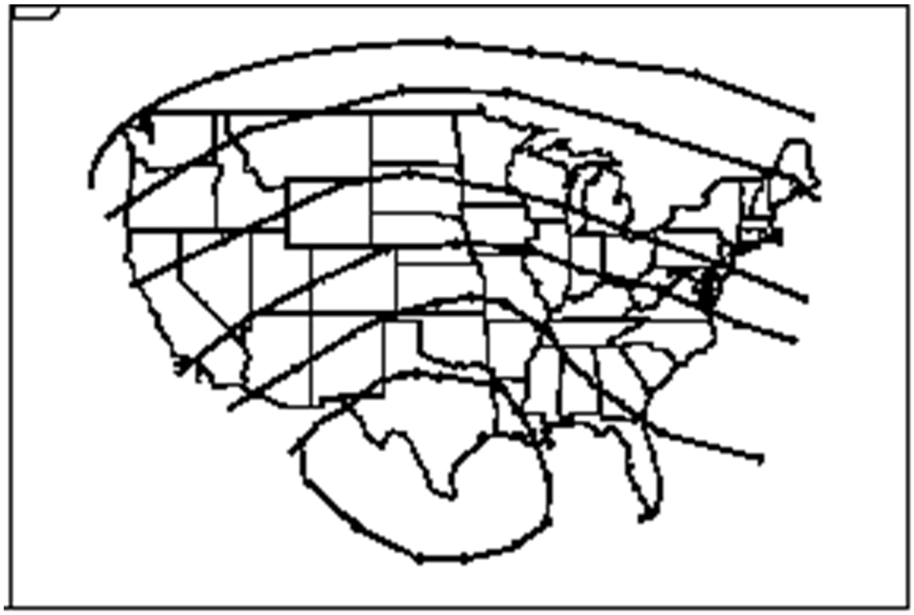
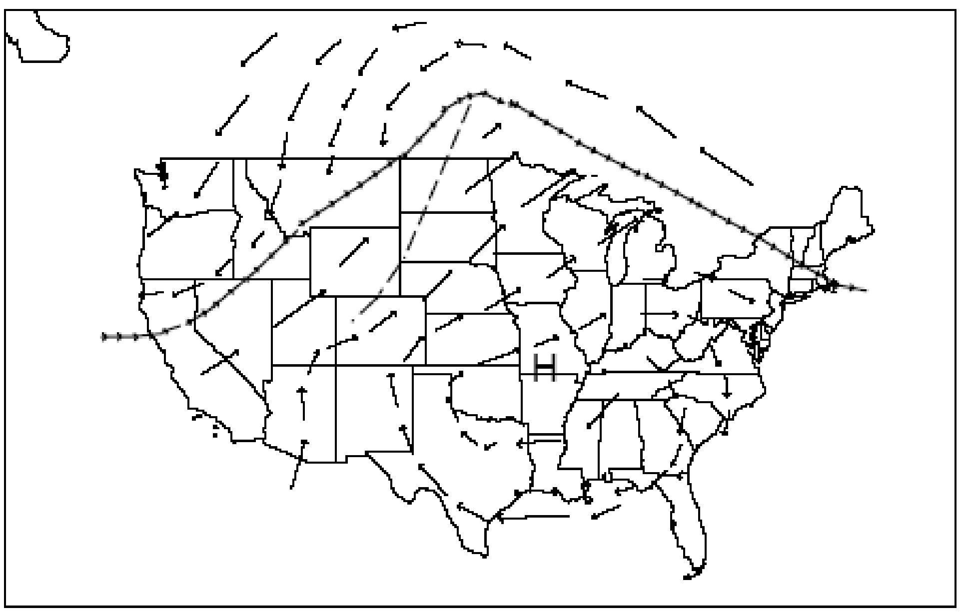


Figure A.7. Surface Air Pattern: Results in weather that is Warm and Moist



The persistence of these weather patterns and the possible resulting condition is the subject of several of the natural disasters discussed in this study. Specifically, floods, droughts, fires, heat waves, severe cold, and winter storms can be the result of the persistence of one of these weather patterns, whereas tornadoes can represent the outgrowth of rapid shifts in weather patterns. Knowing these patterns may assist in alerting disaster planners and the general public to the possibility of a developing emergency situation.

Dam Failure – State Vulnerability Tables

Table A.7 provides a list of high hazard potential dams that have been identified by the state with their names, National Inventory of Dams (NID) identification numbers, locations by jurisdiction, and other relevant information. Additional information for all of the dams is available from the National Inventory of Dams: https://nid.sec.usace.army.mil/#/ Note, private and federal dams are not eligible for FEMA's High Hazard Potential Dam grant program and are thus not included in the table below.

Table A.7. List of High Hazard Potential Dams in Missouri

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Forest Lake Dam	MO10128	CITY OF KIRKSVILLE	Local Government	Adair	KIRKSVILLE	CHARITON RIVER
Savannah City Reservoir Dam	MO10038	CITY OF SAVANNAH	Local Government	Andrew	AMAZONIA	MACE CREEK
Missouri Power and Light Dam	MO10065	CITY OF MEXICO	Local Government	Audrain	MEXICO	TR-SOUTH FORK OF SALT RIVER
Lamar Lake Dam	MO20002	CITY OF LAMAR	Local Government	Barton	LAMAR	TR TO NORTH FORK SPRING RIVER
Adrian Resevoir Dam	MO20005	CITY OF ADRIAN	Local Government	Bates	URICH	TR-BIG DEER CREEK
Appleton City Lake Dam	MO20047	CITY OF APPLETON	Local Government	Bates	TABERVILLE	TR-PANTHER CREEK
Drexel Lake Dam	MO20046	CITY OF DREXEL	Local Government	Bates	DREXEL	NORTH SUGAR CREEK
Callahan Creek A-1	MO11646	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	CALLAHAN CR
Callahan Creek C-2	MO11774	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	BARCLAY BR
Columbia Mum. Golf Course Dam	MO11068	COLUMBIA PARK & REC DEPT	Local Government	Boone	COLUMBIA	TR-HARMONY CREEK
Columbia Mun Golf Course Lower L. Dam	MO10895	CITY OF COLUMBIA	Local Government	Boone	MCBAINE	TRIBUTARY TO HARMONY CREEK
Moores Lake Dam	MO11173	CITY OF COLUMBIA	Local Government	Boone	COLUMBIA	TR-BEAR CREEK
Turkey Farm Lake Dam	MO10552	UNIVERSITY OF MISSOURI	State	Boone	JEFFERSON CITY	TR LITTLE CEDAR CREEK
Univ of Mo-R1 Dam	MO11606	UNIVERSITY OF MISSOURI	State	Boone	WILTON	TR GANS CREEK
Belcher Branch Lake Dam	MO12290	MO DEPT OF CONSERVATION	State	Buchanan	FAUCETT	TR-BELCHER BRANCH
Dearborn Reservoir Dam	MO10426	CITY OF DEARBORN	Local Government	Buchanan	DEARBORN @	TR-BEE CREEK
City of Breckenridge Dam	MO10645	CITY OF BRECKENRIDGE	Local Government	Caldwell	BEDFORD	TR-PANTHER CREEK
Hamilton City Water Plant Dam	MO10261	MAYOR DANNY ALEXANDER	Local Government	Caldwell	HAMILTON	TOM CREEK
Baumgartner Lake Dam	MO12278	JAMES BAUMGARTNER	State	Callaway	HOLTS SUMMIT	CASON BRANCH
Little Dixie Lake Dam	MO10888	MO DEPT OF CONSERVATION	State	Callaway	MILLERSBURG	OWL CREEK
Whetstone Creek Big Lake Dam	MO10876	MO DEPT OF CONSERVATION	State	Callaway	MINEOLA	TR WHETSTONE CREEK
City of Cape Girardeau Dam	MO40109		Local Government	Cape Girardeau		
Lake Boutin Dam	MO40008	MO. DNR PARKS	State	Cape Girardeau	NEELYS LANDING	TR-FLORA CREEK
Lake Girardeau Dam	MO30066	MO DEPT OF CONSERVATION	State	Cape Girardeau	DONGOLA	TR-CROOKED CREEK
Big Creek-Hurricane Creek S- 12	MO50809	BIG CREEK WATERSHED SUBDISTRIC	Local Government	Carroll	NONE	TR-BIG CREEK
City Lake Dam	MO20314	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Harrisonville City Lake Dam	MO20077	CITY OF HARRISONVILLE	Local Government	Cass	PLEASANT HILL	TR MIDDLE BIG CREEK
Lake Luna Dam	MO20076	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Peculiar City Resevoir Dam	MO20305	CITY OF PECULIAR	Local Government	Cass	HARRISONVILLE	TR-WOLF CREEK BRANCH
Pleasant Hill Lake Dam	MO20004	CITY OF PLEASANT HILL	Local Government	Cass	PLEASANT HILL	TR-WILSON CREEK
Marceline New Reservoir Dam	MO12127	CITY OF MARCELINE	Local Government	Chariton	ROTHVILLE	SLATER BRANCH
Fox Valley Dam	MO12197	MO DEPT OF CONSERVATION	State	Clark	KAHOKA	FOX CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Wyaconda City Dam	MO10009	CITY OF WYACONDA	Local Government	Clark	MEDILL	TR-SOUTH WYACONDA RIVER
Watkins Mill State Park Dam	MO10011	MO. DNR PARKS	State	Clay	PRATHERSVILLE	TR-WILLIAMS CREEK
Plattsburg Old Reservoir Dam	MO10267	CITY OF PLATTSBURG	Local Government	Clinton	PLATTSBURG	TR TO LITTLE PLATTE RIVER
Binder Community Lake Dam	MO30051	MO DEPT OF CONSERVATION	State	Cole	JEFFERSON CITY	DICKERSON CR
Hough Park Dam	MO30022	DEPT OF PARKS & REC	Local Government	Cole	JEFFERSON CITY	TR MOREAU RIVER
City Park Lake Dam	MO30588	CITY OF SULLIVAN	Local Government	Crawford	SULLIVAN	TRIBUTARY TO STATER CREEK
Grindstone Lmc F-30	MO12113	WILLIAM F. TUCKER	Local Government	Daviess	SANTA ROSA	TR-LAZY CREEK
Buffalo Bill Dam	MO12201	MO DEPT OF CONSERVATION	State	DeKalb	PATTONSBURG	TRIB WEST FORK LOST CREEK
Cameron #3 Dam	MO10170	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TR-GRINDSTONE CREEK
Cameron City Reservoir #1 Dam	MO10042	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Cameron Reservoir #2 Dam	MO10169	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-26	MO50089	GRNSTN-LST-MDY WRSD SBDS	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-39	MO10299	GRNDSTN-LST-MDY WRSD SBD	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam B-21	MO10310	GRNSN-LS-MD WRSD SBDISTR	Local Government	DeKalb	PATTONSBURG	TR-WEST FORK CREEK
King Lake Dam	MO10384	MO DEPT OF CONSERVATION	Local Government	DeKalb	WEATHERBY	LOST CREEK
Maysville New City Dam	MO12375	CITY OF MAYSVILLE	Local Government	DeKalb		
Maysville New Reservoir Dam	MO10670	CITY OF MAYSVILLE	Local Government	DeKalb	MAYSVILLE	TR TO WEST FORK LOST CREEK
Pony Express Lake Dam	MO10171	MO DEPT OF CONSERVATION	State	DeKalb	SANTA ROSA	TR-WEST FORK LOST CREEK
Indian Trail Fish Hatchery Lake Dam	MO30054	MO DEPT OF CONSERVATION	State	Dent	SLIGO	CROOKED CREEK
Port Hudson Lake Dam	MO31981	MO DEPT OF CONSERVATION	State	Franklin	GERALD	CEDAR FORK
King City New Reservoir Dam	MO10078	KING CITY,MISSOURI	Local Government	Gentry	SANTA ROSA	TR-WILLOW CREEK
Limpp Lake Dam	MO10101	MO DEPT OF CONSERVATION	State	Gentry	UNION STAR	TR-THIRD FORK PLATTE RIVER
Middle Fork Water Company Dam	MO40173		Public Utility	Gentry	DARLINGTON	LINN CREEK
Fellows Lake Dam	MO20036	CITY OF SPRINGFIELD,MO	Local Government	Greene	SPRINGFIELD	LITTLE SAC RIVER
Lake Springfield Dam	MO20023	SPRINGFIELD CITY UTILIT.	Local Government	Greene	BATTLEFIELD	JAMES RIVER
Rainbow Lake Dam	MO20394	PAUL OLIVE	State	Greene	ALDRICH	TR-SIMS BR N DRY SAC RIVER
Bethany City Reservoir Dam	MO10051	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO EAST FORK BIG CK
City of Bethany Dam	MO10071	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO WEST FORK BIG CK
Panther Creek C-2	MO10614	JACK FINE HARR.S&W CDIST	Local Government	Harrison	MOUNT MORIAH	PANTHER CREEK
West Fork of Big Creek C-1 Dam	MO12370	HARRISON COUNTY	Local Government	Harrison	BETHANY	LITTLE CREEK
Frank Milne Dam (Dry)	MO11029	MO DEPT OF CONSERVATION	State	Holt	ST JOSEPH	WHALES CREEK
Fayette New City Lake Dam	MO10130	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR-ADAMS FORK
New Horticulture Farm Dam	MO10790	UNIV MO-COLUMBIA	State	Howard	FRANKLIN	TR COTTONWOOD CREEK
Reservoir Dam	MO10001	UNIV.MO/COLUMBIA	State	Howard	FRANKLIN	COTTONWOOD CREEK
Rogers Lake Dam	MO10370	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR ADAMS FORK
Sims Valley Community Lake Dam	MO30055	MO DEPT OF CONSERVATION	State	Howell	HUTTON VALEY	TR ELEVEN POINT RIVER
Shepard Mountain Dam	MO30324	CITY OF IRONTON	Local Government	Iron	ARCADIA	TR-STOUTS CREEK
Adams Dairy Parkway Dam	MO20793		Local Government	Jackson	GRAIN VALLEY	TRIB BLUE BRANCH

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Lake Jacomo Dam	MO10045	JACKSON COUNTY	Local Government	Jackson	LEES SUMMIT	EAST FORK LITTLE BLUE RIVER.
Lone Jack Lake Dam	MO20768	MO DEPT OF CONSERVATION	State	Jackson	LONEJACK	TRIB TO THE SNI-A-BAR
Prairie Hollow Lake Dam	MO20777	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	BIG CREEK TRIBUTARY
Prairie Lee Lake Dam	MO10044	JACKSON COPARKS & REC	Local Government	Jackson	BLUE SPRINGS	EAST FORK LITTLE BLUE RIVER
Reed Area No 3	MO20032	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	TR BIG CREEK
Tarsney Lake Dam	MO20136	JACKSON CO. PUBLIC WORKS	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Wood Lake Dam	MO20135	CITY OF TARSNEY LAKES	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Pine Lake Dam	MO30447	MO STATE HWY COMMISSION	State	Jefferson	IMPERIAL	TR-ROCK CREEK
E.Br So Fk Blackwater B-19	MO20438	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS	TR-E.BR SO FK.BLACKWATER
E.Br So Fk Blackwater E-24	MO50228	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS, M	TR-E.BR.SO.FK.BLACKWATER
Holden New City Reservoir	MO20532	CITY OF HOLDEN	Local Government	Johnson	KINGSVILLE	TRIB SOUTH FORK BLACKWATER
Holden Reservoir Dam West	MO20194	CITY OF HOLDEN	Local Government	Johnson	HOLDEN	TR-PIN OAK CREEK
Pertle Springs Dam	MO20044	CENTRAL MO STATE COLLEGE	State	Johnson	WARRENSBURG	TR-EAST FORK POST OAK CREEK
Henry Sever Dam	MO10110	MO DEPT OF CONSERVATION	State	Knox	NEWARK	MEYERS BRANCH
Ford Lake Dam	MO11225	LAFAYETTE SOIL & WATER	Local Government	Lafayette	LEXINGTON	TR EAST FORK SNI-A-BAR CREEK
Little Sni-A-Bar #21	MO12103	LITTLE SNI-A-BAR WATERSHED	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #22	MO11970	LITTLE SNI-A-BAR WATERSHED DIS	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #23	MO11235	LAF SOIL&WTR CONS DIST	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Odessa City Lake Dam	MO20042	CITY OF ODESSA	Local Government	Lafayette	WELLINGTON	TR-EAST FORK SNI-A-BAR CREEK
Wellington Nap C-21	MO10284	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington Nap C-22	MO11228	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR TO MISSOURI RIVER
Wellington Nap C-23	MO10283	LAFAYETTE SOIL & WATER	Local Government	Lafayette	CAMDEN	TR MISSOURI RIVER
Wellington Nap D-21a	MO12000	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington-Nap Wtrshd F-21 Dam	MO10282	WLNGTN-NAP WRSD SUBDISTR	Local Government	Lafayette	NAPOLEON	TR TO HICKLIN BR
Buck-Doe Run Watershed Structure #27a	MO11333	BUCK DOE RUN WSD SUBDST	Local Government	Lewis	CANTON	ARTESIAN BRANCH
City of Lewistown Dam	MO10349	CITY OF LEWISTOWN	Local Government	Lewis	TAYLOR	TR-MIDDLE FABIUS RIVER
Deer Ridge Community Lake Dam	MO10109	MO DEPT OF CONSERVATION	State	Lewis	MONTICELLO	TR-NORTH FABIUS RIVER
La Belle Old City Lake Dam	MO10372	CITY OF LA BELLE	Local Government	Lewis	STEFFENVILLE	TR TROUBLESOME CREEK
Clarence Cannon #15	MO11309	LINCOLN CO SOIL&WATER D	Local Government	Lincoln	ELSBERRY	BRYANTS CREEK
Lake Lincoln Dam	MO10215	MO. DNR PARKS	State	Lincoln	TROY	DRY BRANCH SUGAR CREEK
Lost Cr Pilot Watershed Dam F-4	MO50335	ROBERT PIRTLE	Local Government	Lincoln	ELSBERRY	TR-LOST CREEK
Lost Creek #1	MO10212	LAMMERT FARMS LP	Local Government	Lincoln	ELSBERRY	LOST CREEK
Lost Creek #2	MO10216	LOST CREEK WTRSD SUBDST	Local Government	Lincoln	NEW HOPE	TR-LOST CREEK
Shady Eighty Ranch Lake Dam	MO11306	MO. DNR PARKS	State	Lincoln	MOSCOW MILLS	TR-SUGAR CREEK
White Lake Dam	MO12220	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	MILL CREEK TRIBUTARY
White Memorial Area Sec-16 Lake Dam	MO11286	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	TR-LITTLE SANDY CREEK
Brookfield Reservoir Dam	MO10183	CITY OF BROOKFIELD	Local Government	Linn	BROOKFIELD	WEST YELLOW CREEK-OFFSTREAM
Bucklin City Lake Dam	MO10056	CITY OF BUCKLIN,MO	Local Government	Linn	KEYTESVILLE	TR-VAN DORSEN CREEK
Linneus Lake Dam	MO10437	CITY OF LINNEUS	Local Government	Linn	LINNEUS	TR-LOCUST CREEK
Marceline City Reservoir Dam	MO10119	CITY OF MARCELINE,MO	Local Government	Linn	KEYTESVILLE	CLARKS CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Santa Fe Country Club	MO10765	CITY OF MARCELINE	Local Government	Linn	MARCELINE	TR-EAST YELLOW CREEK
Indian Creek Community Dam	MO12221	MO DEPT OF CONSERVATION	State	Livingston	FARMERSVILLE	INDIAN CREEK (TRIBUTARY)
Macon Lake Dam	MO10153	CITY OF MACON	Local Government	Macon	MACON	DUCK CREEK
New Cambria Lake Dam	MO10387	CITY OF NEW CAMBRIA	Local Government	Macon	NEW CAMBRIA	TR CHARITON RIVER
Southwest City Rc&D Structure E-1	MO20510	MCDON CSW CONS DIST SWC	Local Government	McDonald	SOUTHWEST CITY	TR-HONEY CREEK
Lake Paho Dam	MO10108	MO DEPT OF CONSERVATION	State	Mercer	SPIKARD	WEST MUDDY CREEK
Manito Dam	MO31853	MO DEPT OF CONSERVATION	State	Moniteau	FORTUNA	LITTLE RICHLAND CREEK
Lake Tom Sawyer Dam	MO10058	MARK TWAIN STATE PARK	State	Monroe	FLORIDA	TR-SALT RIVER
Monroe City South Lake Dam	MO10538	CITY OF MONROE	Local Government	Monroe	STOUTSVILLE	TR.TO LITTLE INDIAN CREEK
Wellsville Lake Dam	MO10947	MO DEPT OF CONSERVATION	State	Montgomery	MINEOLA	TR-LITTLE LOUTRE CREEK
Hickory Creek Watershed Structure H- 1a	MO51152	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 2a	MO51159	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 9a	MO51148	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 10d	MO51150	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 11	MO51149	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Lost Creek B-2	MO20730	LOST CREEK WATERSHED S.D	Local Government	Newton	RACINE	LOST CREEK
Lost Creek D-1	MO20731	NEWTON CO.SOIL CON. DIST	Local Government	Newton	SENECA	MCDOUGLE CREEK
Lost Creek E-1	MO20511	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek F-3	MO20514	LOST CK WATERSHED SUBDIS	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-1	MO20512	LOST CREEK WRSD SUBDIST	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-2	MO20513	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Site A-1	MO20781	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
Lost Creek Watershed Site C-2	MO20782	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
102 Riv Trib Wtrshd Strctr Lt-36	MO11258	102 RIV TRIB WRSD SUBDST	Local Government	Nodaway	ARKOE	TR-102 RIVER
102 River Tributaries Dam C-5	MO10996	102 RIV TRIB WRSD SUBDIS	Local Government	Nodaway	MARYVILLE	CANAL BRANCH 102 RIVER
Mozingo Creek Dam	MO12277	CITY OF MARYVILLE	Local Government	Nodaway	MARYVILLE	MOZINGO CREEK
Nodaway Lake Dam	MO10178	MO DEPT OF CONSERVATION	State	Nodaway	MARYVILLE	TR-CANAL BRANCH
Ben Branch Dam	MO31844	MO DEPT OF CONSERVATION	State	Osage	LUYSTOWN	BEN BRANCH
Perry County Comm. Lake Dam	MO30813	MO DEPT OF CONSERVATION	State	Perry	SAINT MARYS	TR-SOUTH FORK SALINE CR
Port Perry Dam	MO30030		State	Perry	SILVER LAKE	TR NATIONS CREEK
Spring Fork Lake Dam	MO30152	CITY OF SEDALIA WATER DP	Local Government	Pettis	SEDALIA	CHEESE CK
Windsor Farrington Park Lake Dam	MO20034	CITY OF WINDSOR	Local Government	Pettis	WINDSOR	TR-ELM BRANCH
William E. Towell Dam	MO30090	MO DEPT OF CONSERVATION	State	Phelps	DILLON	TRIBUTARY OF BOUBEUSE RIVER
Bowling Green Dam #1	MO10262		Local Government	Pike	BOWLING GREEN	TRIBUTARY TO NOIX CREEK
Bowling Green Dam #2	MO12195	CITY OF BOWLING GREEN	Local Government	Pike	BOWLING GREEN	TR BUCKNER HOLLOW
Old Bowling Green Reservoir Dam	MO10263	CITY OF BOWLING GREEN	Local Government	Pike	LOUISIANA	TR-BUCKNER HOLLOW-NOIX CREEK
International Airport Dam	MO10661	CITY OF KANSAS CITY MO	Local Government	Platte	PLATTE CITY	TR TODD CREEK
Unionville Old City Lake Dam	MO10152	UNIONVILLE,MO	Local Government	Putnam	UNIONVILLE	TR-BLACKBIRD CREEK
Bear Creek Dam	MO10977	CITY OF HANNIBAL	Local Government	Ralls	HANNIBAL	BEAR CREEK
Perry City Dam - Lower	MO10675	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH LICK CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Perry City Dam No. 2	MO10980	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH
Higbee Lake Dam	MO10222	MARSHALL BAKER	Local Government	Randolph	BURTON	SALT FK BONNE FEMME CREEK
Rothwell Lake Dam	MO10004	MOBERLY PARKS & RECREATN	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Thomas Hill Reservoir Dam	MO10134	ASSOCIATED ELECTRIC CORP	Public Utility	Randolph	THOMAS HILL	MIDDLE FORK CHARITON RIVER
Water Works Lake Dam	MO10006	MOBERLY-PARKS&RECREATION	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Lawson City Lake Dam	MO10147	CITY OF LAWSON	Local Government	Ray	ELMIRA	BRUSHY CREEK
Ray County Lake Dam	MO10098	RAY COUNTY COURT	Local Government	Ray	HODGE	TR-WEST FORK CROOKED RIVER
Richmond Schools Dam	MO10588	RICHMOND SCHOOL DIST R16	Local Government	Ray	HENRIETTA	LICK CREEK
Willow Creek Wtrshd Site A-1	MO11084	WILLOW CREEK WTRSD SUBDS	Local Government	Ray	HENRIETTA	WILLOW CREEK
Taum Sauk Ps Lower	MO30041	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Taum Sauk Ps Upper	MO30040	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Fourche Creek Wtrshd No. 7	MO31408	RIPLEY SOIL/WATER CONSER	Local Government	Ripley	POCAHONTAS ARK	EAST FORK FOURCHE CREEK
Upper Little Black A-2	MO31938	UPPER LITTLE BLACK WATERSHED SUBDISTRICT	Local Government	Ripley	GRANDIN	BEAVER DAM CREEK
Upper Little Black A-7 Dam	MO31829	UPPER LITTLE BLACK SUBD	Local Government	Ripley	GRANDIN	LITTLE BLACK
Upper Little Black D-2	MO31899	UPPER L.BLACK SUBDIST.	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Upper Little Black D-8 Dam	MO31861	DR. MICHAEL SPEZIA	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Van Meter Dam	MO10658	MO. DNR PARKS	State	Saline	MIAMI	TR MISSOURI RIVER
Lancaster City Dam	MO10851	CITY OF LANCASTER	Local Government	Schuyler	LANCASTER	NO.FORK/MIDDLE FAUBIUS RIVER
Queen City Reservoir Dam	MO10186	QUEEN CITY,MO	Local Government	Schuyler	GREENTOP	#NAME?
Memphis Lake Dam	MO10217		Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Memphis Reservoir Dam	MO10163	CITY OF MEMPHIS	Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Caney Basin Dam	MO40070	LITTLE RVR DRAINAGE DIST	Local Government	Scott	ORAN	CANEY CREEK
Tywappity Community Lake Dam	MO40006	MO DEPT OF CONSERVATION	State	Scott	KELSO	HINDMAN CREEK
Clarence City New Lake Dam	MO10608	CITY OF CLARENCE	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Clarence City Old Lake	MO10609	CITY OF CLARENCE,MO	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Shelbina Lake Dam	MO10057	CITY OF SHELBINA	Local Government	Shelby	FLORIDA	TR TO SALT RIVER
Shelbyville Lake Dam	MO10028	CITY OF SHELBYVILLE	Local Government	Shelby	SHELBYVILLE	TR-BLACK CREEK
August A Busch Lake #16 Dam	MO10089	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CR
August A Busch Lake #51 Dam	MO10093	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR SCHOTE CREEK
August A Busch Lake #570 Dam	MO10095	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-DARDENNE CR
Busch Wildlife #35	MO10092	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CREEK
Busch Wildlife #37 Dam	MO10088	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-KRAUT RUN
Sioux Power Plant Dam	MO40160		Public Utility	St. Charles	PORTAGE DES SIOUX	T MISSISSIPPI
Stergen Lake Dam	MO30606	DESPENA STERGEN	State	St. Charles	FEMME OSAGE	TR-FEMME OSAGE CREEK
Univ Mo Exp Farm Dam- Mononame 207	MO10643	MO DEPT OF CONSERVATION	State	St. Charles	WELDON SPRING	EAST BRANCH OF CROOKED CREEK
H&S Hill Top Lake Dam	MO31189		State	St. Francois	BELLEFONTAME	TR-BIG RIVER
Lakeview Park Dam	MO30288	CITY OF BONNE TERRE	Local Government	St. Francois	BONNE TERRE	TURKEY CREEK
St. Joe State Park Dam	MO30277	MO. DNR PARKS	State	St. Francois	FLAT RIVER	SHAW BRANCH-FLAT RIVER
Bee Tree Lake Dam	MO31378	ST. LOUIS COUNTY	Local Government	St. Louis	HERCULANEUM	TR TO MERAMEC RIVER
City of Fenton Dam #1	MO40138		Local Government	St. Louis	FENTON	

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
City Place Dam	MO31914	CITY OF CREVE COEUR	Local Government	St. Louis	CREVE COEUR	TR CREVE COEUR CREEK
Stacy Park Resevoir Dam	MO31658	CITY OF ST. LOUIS	Local Government	St. Louis	OLIVETTE	RIVER DES PERES
Duck Creek State Wildlife Refuge No 2	MO40093	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek State Wildlife Refuge No 3	MO40094	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek-State Wildlife Refuge-# 1	MO40063	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	CASTOR RIVER
Southwest Rc & D # 1 Dam	MO20509	CITY OF CRANE	Local Government	Stone	CRANE	TR-CRANE CREEK
Elmwood City Lake Dam	MO10240	CITY OF MILAN	Local Government	Sullivan	MILAN	ELMWOOD BRANCH
Sears Community Lake Dam	MO10503	MO DEPT OF CONSERVATION	State	Sullivan	MILAN	TR-EAST LOCUST CREEK
Ozark Beach	MO30088	Empire District Electric Company	Public Utility	Taney	Forsyth	White River
Austin Community Lake Dam	MO30074	MO DEPT OF CONSERVATION	State	Texas	MANES	TR-BEAVER CREEK
Izaak Walton Lake Dam	MO20048	CITY OF NEVADA	Local Government	Vernon	NEVADA	TR TO WHITE BRANCH
Marthasville Mv-5 Dam	MO40111	CITY OF MARTHASVILLE	Local Government	Warren	MARTHASVILLE	TRIB TO TUQUE CREEK
Casey Lake Dam	MO30695	CASEY WOJCIECHOWSKI	State	Washington	LEADWOOD	TR-CLEAR CREEK
Lac Shayne Dam	MO31835	TERRE DU LAC POA	Local Government	Washington	TERRE DU LAC	POND CREEK
Lake Apache Dam	MO30703	CITY OF IRONDALE	Local Government	Washington	IRONDALE	TR DRY CREEK
Eagle Sky Lake Dam	MO30007	CLAUDE KENNEDY	State	Wayne	PATTERSON	CAMP CREEK
Platte River Trib Watershed Dam 3-B	MO11054	PLATTE RVR TR WTSH DIST.	Local Government	Worth	SHERIDAN	TR-PLATTE RIVER
Dam Name	**NID ID**	**Owner Names**	**Owner Types**	**County**	**City**	**River or Stream Name**
Forest Lake Dam	MO10128	CITY OF KIRKSVILLE	Local Government	Adair	KIRKSVILLE	CHARITON RIVER
Savannah City Reservoir Dam	MO10038	CITY OF SAVANNAH	Local Government	Andrew	AMAZONIA	MACE CREEK
Missouri Power and Light Dam	MO10065	CITY OF MEXICO	Local Government	Audrain	MEXICO	TR-SOUTH FORK OF SALT RIVER
Lamar Lake Dam	MO20002	CITY OF LAMAR	Local Government	Barton	LAMAR	TR TO NORTH FORK SPRING RIVER
Adrian Resevoir Dam	MO20005	CITY OF ADRIAN	Local Government	Bates	URICH	TR-BIG DEER CREEK
Appleton City Lake Dam	MO20047	CITY OF APPLETON	Local Government	Bates	TABERVILLE	TR-PANTHER CREEK
Drexel Lake Dam	MO20046	CITY OF DREXEL	Local Government	Bates	DREXEL	NORTH SUGAR CREEK
Callahan Creek A-1	MO11646	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	CALLAHAN CR
Callahan Creek C-2	MO11774	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	BARCLAY BR
Columbia Mum. Golf Course Dam	MO11068	COLUMBIA PARK & REC DEPT	Local Government	Boone	COLUMBIA	TR-HARMONY CREEK
Columbia Mun Golf Course Lower L. Dam	MO10895	CITY OF COLUMBIA	Local Government	Boone	MCBAINE	TRIBUTARY TO HARMONY CREEK
Moores Lake Dam	MO11173	CITY OF COLUMBIA	Local Government	Boone	COLUMBIA	TR-BEAR CREEK
Turkey Farm Lake Dam	MO10552	UNIVERSITY OF MISSOURI	State	Boone	JEFFERSON CITY	TR LITTLE CEDAR CREEK
Univ of Mo-R1 Dam	MO11606	UNIVERSITY OF MISSOURI	State	Boone	WILTON	TR GANS CREEK
Belcher Branch Lake Dam	MO12290	MO DEPT OF CONSERVATION	State	Buchanan	FAUCETT	TR-BELCHER BRANCH
Dearborn Reservoir Dam	MO10426	CITY OF DEARBORN	Local Government	Buchanan	DEARBORN @	TR-BEE CREEK
City of Breckenridge Dam	MO10645	CITY OF BRECKENRIDGE	Local Government	Caldwell	BEDFORD	TR-PANTHER CREEK
Hamilton City Water Plant Dam	MO10261	MAYOR DANNY ALEXANDER	Local Government	Caldwell	HAMILTON	TOM CREEK
Baumgartner Lake Dam	MO12278	JAMES BAUMGARTNER	State	Callaway	HOLTS SUMMIT	CASON BRANCH
Little Dixie Lake Dam	MO10888	MO DEPT OF CONSERVATION	State	Callaway	MILLERSBURG	OWL CREEK
Whetstone Creek Big Lake Dam	MO10876	MO DEPT OF CONSERVATION	State	Callaway	MINEOLA	TR WHETSTONE CREEK
City of Cape Girardeau Dam	MO40109		Local Government	Cape Girardeau		

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Lake Boutin Dam	MO40008	MO. DNR PARKS	State	Cape Girardeau	NEELYS LANDING	TR-FLORA CREEK
Lake Girardeau Dam	MO30066	MO DEPT OF CONSERVATION	State	Cape Girardeau	DONGOLA	TR-CROOKED CREEK
Big Creek-Hurricane Creek S- 12	MO50809	BIG CREEK WATERSHED SUBDISTRIC	Local Government	Carroll	NONE	TR-BIG CREEK
City Lake Dam	MO20314	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Harrisonville City Lake Dam	MO20077	CITY OF HARRISONVILLE	Local Government	Cass	PLEASANT HILL	TR MIDDLE BIG CREEK
Lake Luna Dam	MO20076	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Peculiar City Resevoir Dam	MO20305	CITY OF PECULIAR	Local Government	Cass	HARRISONVILLE	TR-WOLF CREEK BRANCH
Pleasant Hill Lake Dam	MO20004	CITY OF PLEASANT HILL	Local Government	Cass	PLEASANT HILL	TR-WILSON CREEK
Marceline New Reservoir Dam	MO12127	CITY OF MARCELINE	Local Government	Chariton	ROTHVILLE	SLATER BRANCH
Fox Valley Dam	MO12197	MO DEPT OF CONSERVATION	State	Clark	KAHOKA	FOX CREEK
Wyaconda City Dam	MO10009	CITY OF WYACONDA	Local Government	Clark	MEDILL	TR-SOUTH WYACONDA RIVER
Watkins Mill State Park Dam	MO10011	MO. DNR PARKS	State	Clay	PRATHERSVILLE	TR-WILLIAMS CREEK
Plattsburg Old Reservoir Dam	MO10267	CITY OF PLATTSBURG	Local Government	Clinton	PLATTSBURG	TR TO LITTLE PLATTE RIVER
Binder Community Lake Dam	MO30051	MO DEPT OF CONSERVATION	State	Cole	JEFFERSON CITY	DICKERSON CR
Hough Park Dam	MO30022	DEPT OF PARKS & REC	Local Government	Cole	JEFFERSON CITY	TR MOREAU RIVER
City Park Lake Dam	MO30588	CITY OF SULLIVAN	Local Government	Crawford	SULLIVAN	TRIBUTARY TO STATER CREEK
Grindstone Lmc F-30	MO12113	WILLIAM F. TUCKER	Local Government	Daviess	SANTA ROSA	TR-LAZY CREEK
Buffalo Bill Dam	MO12201	MO DEPT OF CONSERVATION	State	DeKalb	PATTONSBURG	TRIB WEST FORK LOST CREEK
Cameron #3 Dam	MO10170	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TR-GRINDSTONE CREEK
Cameron City Reservoir #1 Dam	MO10042	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Cameron Reservoir #2 Dam	MO10169	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-26	MO50089	GRNSTN-LST-MDY WRSD SBDS	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-39	MO10299	GRNDSTN-LST-MDY WRSD SBD	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam B-21	MO10310	GRNSN-LS-MD WRSD SBDISTR	Local Government	DeKalb	PATTONSBURG	TR-WEST FORK CREEK
King Lake Dam	MO10384	MO DEPT OF CONSERVATION	Local Government	DeKalb	WEATHERBY	LOST CREEK
Maysville New City Dam	MO12375	CITY OF MAYSVILLE	Local Government	DeKalb		
Maysville New Reservoir Dam	MO10670	CITY OF MAYSVILLE	Local Government	DeKalb	MAYSVILLE	TR TO WEST FORK LOST CREEK
Pony Express Lake Dam	MO10171	MO DEPT OF CONSERVATION	State	DeKalb	SANTA ROSA	TR-WEST FORK LOST CREEK
Indian Trail Fish Hatchery Lake Dam	MO30054	MO DEPT OF CONSERVATION	State	Dent	SLIGO	CROOKED CREEK
Port Hudson Lake Dam	MO31981	MO DEPT OF CONSERVATION	State	Franklin	GERALD	CEDAR FORK
King City New Reservoir Dam	MO10078	KING CITY,MISSOURI	Local Government	Gentry	SANTA ROSA	TR-WILLOW CREEK
Limpp Lake Dam	MO10101	MO DEPT OF CONSERVATION	State	Gentry	UNION STAR	TR-THIRD FORK PLATTE RIVER
Middle Fork Water Company Dam	MO40173		Public Utility	Gentry	DARLINGTON	LINN CREEK
Fellows Lake Dam	MO20036	CITY OF SPRINGFIELD,MO	Local Government	Greene	SPRINGFIELD	LITTLE SAC RIVER
Lake Springfield Dam	MO20023	SPRINGFIELD CITY UTILIT.	Local Government	Greene	BATTLEFIELD	JAMES RIVER
Rainbow Lake Dam	MO20394	PAUL OLIVE	State	Greene	ALDRICH	TR-SIMS BR N DRY SAC RIVER
Bethany City Reservoir Dam	MO10051	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO EAST FORK BIG CK
City of Bethany Dam	MO10071	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO WEST FORK BIG CK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Panther Creek C-2	MO10614	JACK FINE HARR.S&W CDIST	Local Government	Harrison	MOUNT MORIAH	PANTHER CREEK
West Fork of Big Creek C-1 Dam	MO12370	HARRISON COUNTY	Local Government	Harrison	BETHANY	LITTLE CREEK
Frank Milne Dam (Dry)	MO11029	MO DEPT OF CONSERVATION	State	Holt	ST JOSEPH	WHALES CREEK
Fayette New City Lake Dam	MO10130	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR-ADAMS FORK
New Horticulture Farm Dam	MO10790	UNIV MO-COLUMBIA	State	Howard	FRANKLIN	TR COTTONWOOD CREEK
Reservoir Dam	MO10001	UNIV.MO/COLUMBIA	State	Howard	FRANKLIN	COTTONWOOD CREEK
Rogers Lake Dam	MO10370	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR ADAMS FORK
Sims Valley Community Lake Dam	MO30055	MO DEPT OF CONSERVATION	State	Howell	HUTTON VALEY	TR ELEVEN POINT RIVER
Shepard Mountain Dam	MO30324	CITY OF IRONTON	Local Government	Iron	ARCADIA	TR-STOUTS CREEK
Adams Dairy Parkway Dam	MO20793		Local Government	Jackson	GRAIN VALLEY	TRIB BLUE BRANCH
Lake Jacomo Dam	MO10045	JACKSON COUNTY	Local Government	Jackson	LEES SUMMIT	EAST FORK LITTLE BLUE RIVER.
Lone Jack Lake Dam	MO20768	MO DEPT OF CONSERVATION	State	Jackson	LONEJACK	TRIB TO THE SNI-A-BAR
Prairie Hollow Lake Dam	MO20777	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	BIG CREEK TRIBUTARY
Prairie Lee Lake Dam	MO10044	JACKSON COPARKS & REC	Local Government	Jackson	BLUE SPRINGS	EAST FORK LITTLE BLUE RIVER
Reed Area No 3	MO20032	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	TR BIG CREEK
Tarsney Lake Dam	MO20136	JACKSON CO. PUBLIC WORKS	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Wood Lake Dam	MO20135	CITY OF TARSNEY LAKES	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Pine Lake Dam	MO30447	MO STATE HWY COMMISSION	State	Jefferson	IMPERIAL	TR-ROCK CREEK
E.Br So Fk Blackwater B-19	MO20438	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS	TR-E.BR SO FK.BLACKWATER
E.Br So Fk Blackwater E-24	MO50228	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS, M	TR-E.BR.SO.FK.BLACKWATER
Holden New City Reservoir	MO20532	CITY OF HOLDEN	Local Government	Johnson	KINGSVILLE	TRIB SOUTH FORK BLACKWATER
Holden Reservoir Dam West	MO20194	CITY OF HOLDEN	Local Government	Johnson	HOLDEN	TR-PIN OAK CREEK
Pertle Springs Dam	MO20044	CENTRAL MO STATE COLLEGE	State	Johnson	WARRENSBURG	TR-EAST FORK POST OAK CREEK
Henry Sever Dam	MO10110	MO DEPT OF CONSERVATION	State	Knox	NEWARK	MEYERS BRANCH
Ford Lake Dam	MO11225	LAFAYETTE SOIL & WATER	Local Government	Lafayette	LEXINGTON	TR EAST FORK SNI-A-BAR CREEK
Little Sni-A-Bar #21	MO12103	LITTLE SNI-A-BAR WATERSHED	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #22	MO11970	LITTLE SNI-A-BAR WATERSHED DIS	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #23	MO11235	LAF SOIL&WTR CONS DIST	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Odessa City Lake Dam	MO20042	CITY OF ODESSA	Local Government	Lafayette	WELLINGTON	TR-EAST FORK SNI-A-BAR CREEK
Wellington Nap C-21	MO10284	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington Nap C-22	MO11228	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR TO MISSOURI RIVER
Wellington Nap C-23	MO10283	LAFAYETTE SOIL & WATER	Local Government	Lafayette	CAMDEN	TR MISSOURI RIVER
Wellington Nap D-21a	MO12000	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington-Nap Wtrshd F-21 Dam	MO10282	WLNGTN-NAP WRSD SUBDISTR	Local Government	Lafayette	NAPOLEON	TR TO HICKLIN BR
Buck-Doe Run Watershed Structure #27a	MO11333	BUCK DOE RUN WSD SUBDST	Local Government	Lewis	CANTON	ARTESIAN BRANCH
City of Lewistown Dam	MO10349	CITY OF LEWISTOWN	Local Government	Lewis	TAYLOR	TR-MIDDLE FABIUS RIVER
Deer Ridge Community Lake Dam	MO10109	MO DEPT OF CONSERVATION	State	Lewis	MONTICELLO	TR-NORTH FABIUS RIVER
La Belle Old City Lake Dam	MO10372	CITY OF LA BELLE	Local Government	Lewis	STEFFENVILLE	TR TROUBLESOME CREEK
Clarence Cannon #15	MO11309	LINCOLN CO SOIL&WATER D	Local Government	Lincoln	ELSBERRY	BRYANTS CREEK
Lake Lincoln Dam	MO10215	MO. DNR PARKS	State	Lincoln	TROY	DRY BRANCH SUGAR CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Lost Cr Pilot Watershed Dam F-4	MO50335	ROBERT PIRTLE	Local Government	Lincoln	ELSBERRY	TR-LOST CREEK
Lost Creek #1	MO10212	LAMMERT FARMS LP	Local Government	Lincoln	ELSBERRY	LOST CREEK
Lost Creek #2	MO10216	LOST CREEK WTRSD SUBDST	Local Government	Lincoln	NEW HOPE	TR-LOST CREEK
Shady Eighty Ranch Lake Dam	MO11306	MO. DNR PARKS	State	Lincoln	MOSCOW MILLS	TR-SUGAR CREEK
White Lake Dam	MO12220	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	MILL CREEK TRIBUTARY
White Memorial Area Sec-16 Lake Dam	MO11286	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	TR-LITTLE SANDY CREEK
Brookfield Reservoir Dam	MO10183	CITY OF BROOKFIELD	Local Government	Linn	BROOKFIELD	WEST YELLOW CREEK-OFFSTREAM
Bucklin City Lake Dam	MO10056	CITY OF BUCKLIN,MO	Local Government	Linn	KEYTESVILLE	TR-VAN DORSEN CREEK
Linneus Lake Dam	MO10437	CITY OF LINNEUS	Local Government	Linn	LINNEUS	TR-LOCUST CREEK
Marceline City Reservoir Dam	MO10119	CITY OF MARCELINE,MO	Local Government	Linn	KEYTESVILLE	CLARKS CREEK
Santa Fe Country Club	MO10765	CITY OF MARCELINE	Local Government	Linn	MARCELINE	TR-EAST YELLOW CREEK
Indian Creek Community Dam	MO12221	MO DEPT OF CONSERVATION	State	Livingston	FARMERSVILLE	INDIAN CREEK (TRIBUTARY)
Macon Lake Dam	MO10153	CITY OF MACON	Local Government	Macon	MACON	DUCK CREEK
New Cambria Lake Dam	MO10387	CITY OF NEW CAMBRIA	Local Government	Macon	NEW CAMBRIA	TR CHARITON RIVER
Southwest City Rc&D Structure E-1	MO20510	MCDON CSW CONS DIST SWC	Local Government	McDonald	SOUTHWEST CITY	TR-HONEY CREEK
Lake Paho Dam	MO10108	MO DEPT OF CONSERVATION	State	Mercer	SPIKARD	WEST MUDDY CREEK
Manito Dam	MO31853	MO DEPT OF CONSERVATION	State	Moniteau	FORTUNA	LITTLE RICHLAND CREEK
Lake Tom Sawyer Dam	MO10058	MARK TWAIN STATE PARK	State	Monroe	FLORIDA	TR-SALT RIVER
Monroe City South Lake Dam	MO10538	CITY OF MONROE	Local Government	Monroe	STOUTSVILLE	TR.TO LITTLE INDIAN CREEK
Wellsville Lake Dam	MO10947	MO DEPT OF CONSERVATION	State	Montgomery	MINEOLA	TR-LITTLE LOUTRE CREEK
Hickory Creek Watershed Structure H- 1a	MO51152	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 2a	MO51159	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 9a	MO51148	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 10d	MO51150	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 11	MO51149	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Lost Creek B-2	MO20730	LOST CREEK WATERSHED S.D	Local Government	Newton	RACINE	LOST CREEK
Lost Creek D-1	MO20731	NEWTON CO.SOIL CON. DIST	Local Government	Newton	SENECA	MCDOUGLE CREEK
Lost Creek E-1	MO20511	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek F-3	MO20514	LOST CK WATERSHED SUBDIS	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-1	MO20512	LOST CREEK WRSD SUBDIST	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-2	MO20513	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Site A-1	MO20781	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
Lost Creek Watershed Site C-2	MO20782	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
102 Riv Trib Wtrshd Strctr Lt-36	MO11258	102 RIV TRIB WRSD SUBDST	Local Government	Nodaway	ARKOE	TR-102 RIVER
102 River Tributaries Dam C-5	MO10996	102 RIV TRIB WRSD SUBDIS	Local Government	Nodaway	MARYVILLE	CANAL BRANCH 102 RIVER
Mozingo Creek Dam	MO12277	CITY OF MARYVILLE	Local Government	Nodaway	MARYVILLE	MOZINGO CREEK
Nodaway Lake Dam	MO10178	MO DEPT OF CONSERVATION	State	Nodaway	MARYVILLE	TR-CANAL BRANCH
Ben Branch Dam	MO31844	MO DEPT OF CONSERVATION	State	Osage	LUYSTOWN	BEN BRANCH
Perry County Comm. Lake Dam	MO30813	MO DEPT OF CONSERVATION	State	Perry	SAINT MARYS	TR-SOUTH FORK SALINE CR
Port Perry Dam	MO30030		State	Perry	SILVER LAKE	TR NATIONS CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Spring Fork Lake Dam	MO30152	CITY OF SEDALIA WATER DP	Local Government	Pettis	SEDALIA	CHEESE CK
Windsor Farrington Park Lake Dam	MO20034	CITY OF WINDSOR	Local Government	Pettis	WINDSOR	TR-ELM BRANCH
William E. Towell Dam	MO30090	MO DEPT OF CONSERVATION	State	Phelps	DILLON	TRIBUTARY OF BOUBEUSE RIVER
Bowling Green Dam #1	MO10262		Local Government	Pike	BOWLING GREEN	TRIBUTARY TO NOIX CREEK
Bowling Green Dam #2	MO12195	CITY OF BOWLING GREEN	Local Government	Pike	BOWLING GREEN	TR BUCKNER HOLLOW
Old Bowling Green Reservoir Dam	MO10263	CITY OF BOWLING GREEN	Local Government	Pike	LOUISIANA	TR-BUCKNER HOLLOW-NOIX CREEK
International Airport Dam	MO10661	CITY OF KANSAS CITY MO	Local Government	Platte	PLATTE CITY	TR TODD CREEK
Unionville Old City Lake Dam	MO10152	UNIONVILLE,MO	Local Government	Putnam	UNIONVILLE	TR-BLACKBIRD CREEK
Bear Creek Dam	MO10977	CITY OF HANNIBAL	Local Government	Ralls	HANNIBAL	BEAR CREEK
Perry City Dam - Lower	MO10675	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH LICK CREEK
Perry City Dam No. 2	MO10980	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH
Higbee Lake Dam	MO10222	MARSHALL BAKER	Local Government	Randolph	BURTON	SALT FK BONNE FEMME CREEK
Rothwell Lake Dam	MO10004	MOBERLY PARKS & RECREATN	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Thomas Hill Reservoir Dam	MO10134	ASSOCIATED ELECTRIC CORP	Public Utility	Randolph	THOMAS HILL	MIDDLE FORK CHARITON RIVER
Water Works Lake Dam	MO10006	MOBERLY-PARKS&RECREATION	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Lawson City Lake Dam	MO10147	CITY OF LAWSON	Local Government	Ray	ELMIRA	BRUSHY CREEK
Ray County Lake Dam	MO10098	RAY COUNTY COURT	Local Government	Ray	HODGE	TR-WEST FORK CROOKED RIVER
Richmond Schools Dam	MO10588	RICHMOND SCHOOL DIST R16	Local Government	Ray	HENRIETTA	LICK CREEK
Willow Creek Wtrshd Site A-1	MO11084	WILLOW CREEK WTRSD SUBDS	Local Government	Ray	HENRIETTA	WILLOW CREEK
Taum Sauk Ps Lower	MO30041	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Taum Sauk Ps Upper	MO30040	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Fourche Creek Wtrshd No. 7	MO31408	RIPLEY SOIL/WATER CONSER	Local Government	Ripley	POCAHONTAS ARK	EAST FORK FOURCHE CREEK
Upper Little Black A-2	MO31938	UPPER LITTLE BLACK WATERSHED SUBDISTRICT	Local Government	Ripley	GRANDIN	BEAVER DAM CREEK
Upper Little Black A-7 Dam	MO31829	UPPER LITTLE BLACK SUBD	Local Government	Ripley	GRANDIN	LITTLE BLACK
Upper Little Black D-2	MO31899	UPPER L.BLACK SUBDIST.	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Upper Little Black D-8 Dam	MO31861	DR. MICHAEL SPEZIA	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Van Meter Dam	MO10658	MO. DNR PARKS	State	Saline	MIAMI	TR MISSOURI RIVER
Lancaster City Dam	MO10851	CITY OF LANCASTER	Local Government	Schuyler	LANCASTER	NO.FORK/MIDDLE FAUBIUS RIVER
Queen City Reservoir Dam	MO10186	QUEEN CITY,MO	Local Government	Schuyler	GREENTOP	#NAME?
Memphis Lake Dam	MO10217		Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Memphis Reservoir Dam	MO10163	CITY OF MEMPHIS	Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Caney Basin Dam	MO40070	LITTLE RVR DRAINAGE DIST	Local Government	Scott	ORAN	CANEY CREEK
Tywappity Community Lake Dam	MO40006	MO DEPT OF CONSERVATION	State	Scott	KELSO	HINDMAN CREEK
Clarence City New Lake Dam	MO10608	CITY OF CLARENCE	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Clarence City Old Lake	MO10609	CITY OF CLARENCE,MO	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Shelbina Lake Dam	MO10057	CITY OF SHELBINA	Local Government	Shelby	FLORIDA	TR TO SALT RIVER
Shelbyville Lake Dam	MO10028	CITY OF SHELBYVILLE	Local Government	Shelby	SHELBYVILLE	TR-BLACK CREEK
August A Busch Lake #16 Dam	MO10089	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CR
August A Busch Lake #51 Dam	MO10093	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR SCHOTE CREEK
August A Busch Lake #570 Dam	MO10095	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-DARDENNE CR

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Busch Wildlife #35	MO10092	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CREEK
Busch Wildlife #37 Dam	MO10088	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-KRAUT RUN
Sioux Power Plant Dam	MO40160		Public Utility	St. Charles	PORTAGE DES SIOUX	T MISSISSIPPI
Stergen Lake Dam	MO30606	DESPENA STERGEN	State	St. Charles	FEMME OSAGE	TR-FEMME OSAGE CREEK
Univ Mo Exp Farm Dam- Mononame 207	MO10643	MO DEPT OF CONSERVATION	State	St. Charles	WELDON SPRING	EAST BRANCH OF CROOKED CREEK
H&S Hill Top Lake Dam	MO31189		State	St. Francois	BELLEFONTAME	TR-BIG RIVER
Lakeview Park Dam	MO30288	CITY OF BONNE TERRE	Local Government	St. Francois	BONNE TERRE	TURKEY CREEK
St. Joe State Park Dam	MO30277	MO. DNR PARKS	State	St. Francois	FLAT RIVER	SHAW BRANCH-FLAT RIVER
Bee Tree Lake Dam	MO31378	ST. LOUIS COUNTY	Local Government	St. Louis	HERCULANEUM	TR TO MERAMEC RIVER
City of Fenton Dam #1	MO40138		Local Government	St. Louis	FENTON	
City Place Dam	MO31914	CITY OF CREVE COEUR	Local Government	St. Louis	CREVE COEUR	TR CREVE COEUR CREEK
Stacy Park Resevoir Dam	MO31658	CITY OF ST. LOUIS	Local Government	St. Louis	OLIVETTE	RIVER DES PERES
Duck Creek State Wildlife Refuge No 2	MO40093	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek State Wildlife Refuge No 3	MO40094	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek-State Wildlife Refuge-# 1	MO40063	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	CASTOR RIVER
Southwest Rc & D # 1 Dam	MO20509	CITY OF CRANE	Local Government	Stone	CRANE	TR-CRANE CREEK
Elmwood City Lake Dam	MO10240	CITY OF MILAN	Local Government	Sullivan	MILAN	ELMWOOD BRANCH
Sears Community Lake Dam	MO10503	MO DEPT OF CONSERVATION	State	Sullivan	MILAN	TR-EAST LOCUST CREEK
Ozark Beach	MO30088	Empire District Electric Company	Public Utility	Taney	Forsyth	White River
Austin Community Lake Dam	MO30074	MO DEPT OF CONSERVATION	State	Texas	MANES	TR-BEAVER CREEK
Izaak Walton Lake Dam	MO20048	CITY OF NEVADA	Local Government	Vernon	NEVADA	TR TO WHITE BRANCH
Marthasville Mv-5 Dam	MO40111	CITY OF MARTHASVILLE	Local Government	Warren	MARTHASVILLE	TRIB TO TUQUE CREEK
Casey Lake Dam	MO30695	CASEY WOJCIECHOWSKI	State	Washington	LEADWOOD	TR-CLEAR CREEK
Lac Shayne Dam	MO31835	TERRE DU LAC POA	Local Government	Washington	TERRE DU LAC	POND CREEK
Lake Apache Dam	MO30703	CITY OF IRONDALE	Local Government	Washington	IRONDALE	TR DRY CREEK
Eagle Sky Lake Dam	MO30007	CLAUDE KENNEDY	State	Wayne	PATTERSON	CAMP CREEK
Platte River Trib Watershed Dam 3-B	MO11054	PLATTE RVR TR WTSH DIST.	Local Government	Worth	SHERIDAN	TR-PLATTE RIVER
Dam Name	**NID ID**	**Owner Names**	**Owner Types**	**County**	**City**	**River or Stream Name**
Forest Lake Dam	MO10128	CITY OF KIRKSVILLE	Local Government	Adair	KIRKSVILLE	CHARITON RIVER
Savannah City Reservoir Dam	MO10038	CITY OF SAVANNAH	Local Government	Andrew	AMAZONIA	MACE CREEK
Missouri Power and Light Dam	MO10065	CITY OF MEXICO	Local Government	Audrain	MEXICO	TR-SOUTH FORK OF SALT RIVER
Lamar Lake Dam	MO20002	CITY OF LAMAR	Local Government	Barton	LAMAR	TR TO NORTH FORK SPRING RIVER
Adrian Resevoir Dam	MO20005	CITY OF ADRIAN	Local Government	Bates	URICH	TR-BIG DEER CREEK
Appleton City Lake Dam	MO20047	CITY OF APPLETON	Local Government	Bates	TABERVILLE	TR-PANTHER CREEK
Drexel Lake Dam	MO20046	CITY OF DREXEL	Local Government	Bates	DREXEL	NORTH SUGAR CREEK
Callahan Creek A-1	MO11646	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	CALLAHAN CR
Callahan Creek C-2	MO11774	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	BARCLAY BR
Columbia Mum. Golf Course Dam	MO11068	COLUMBIA PARK & REC DEPT	Local Government	Boone	COLUMBIA	TR-HARMONY CREEK
Columbia Mun Golf Course Lower L. Dam	MO10895	CITY OF COLUMBIA	Local Government	Boone	MCBAINE	TRIBUTARY TO HARMONY CREEK
Moores Lake Dam	MO11173	CITY OF COLUMBIA	Local Government	Boone	COLUMBIA	TR-BEAR CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Turkey Farm Lake Dam	MO10552	UNIVERSITY OF MISSOURI	State	Boone	JEFFERSON CITY	TR LITTLE CEDAR CREEK
Univ of Mo-R1 Dam	MO11606	UNIVERSITY OF MISSOURI	State	Boone	WILTON	TR GANS CREEK
Belcher Branch Lake Dam	MO12290	MO DEPT OF CONSERVATION	State	Buchanan	FAUCETT	TR-BELCHER BRANCH
Dearborn Reservoir Dam	MO10426	CITY OF DEARBORN	Local Government	Buchanan	DEARBORN @	TR-BEE CREEK
City of Breckenridge Dam	MO10645	CITY OF BRECKENRIDGE	Local Government	Caldwell	BEDFORD	TR-PANTHER CREEK
Hamilton City Water Plant Dam	MO10261	MAYOR DANNY ALEXANDER	Local Government	Caldwell	HAMILTON	TOM CREEK
Baumgartner Lake Dam	MO12278	JAMES BAUMGARTNER	State	Callaway	HOLTS SUMMIT	CASON BRANCH
Little Dixie Lake Dam	MO10888	MO DEPT OF CONSERVATION	State	Callaway	MILLERSBURG	OWL CREEK
Whetstone Creek Big Lake Dam	MO10876	MO DEPT OF CONSERVATION	State	Callaway	MINEOLA	TR WHETSTONE CREEK
City of Cape Girardeau Dam	MO40109		Local Government	Cape Girardeau		
Lake Boutin Dam	MO40008	MO. DNR PARKS	State	Cape Girardeau	NEELYS LANDING	TR-FLORA CREEK
Lake Girardeau Dam	MO30066	MO DEPT OF CONSERVATION	State	Cape Girardeau	DONGOLA	TR-CROOKED CREEK
Big Creek-Hurricane Creek S- 12	MO50809	BIG CREEK WATERSHED SUBDISTRIC	Local Government	Carroll	NONE	TR-BIG CREEK
City Lake Dam	MO20314	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Harrisonville City Lake Dam	MO20077	CITY OF HARRISONVILLE	Local Government	Cass	PLEASANT HILL	TR MIDDLE BIG CREEK
Lake Luna Dam	MO20076	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Peculiar City Resevoir Dam	MO20305	CITY OF PECULIAR	Local Government	Cass	HARRISONVILLE	TR-WOLF CREEK BRANCH
Pleasant Hill Lake Dam	MO20004	CITY OF PLEASANT HILL	Local Government	Cass	PLEASANT HILL	TR-WILSON CREEK
Marceline New Reservoir Dam	MO12127	CITY OF MARCELINE	Local Government	Chariton	ROTHVILLE	SLATER BRANCH
Fox Valley Dam	MO12197	MO DEPT OF CONSERVATION	State	Clark	KAHOKA	FOX CREEK
Wyaconda City Dam	MO10009	CITY OF WYACONDA	Local Government	Clark	MEDILL	TR-SOUTH WYACONDA RIVER
Watkins Mill State Park Dam	MO10011	MO. DNR PARKS	State	Clay	PRATHERSVILLE	TR-WILLIAMS CREEK
Plattsburg Old Reservoir Dam	MO10267	CITY OF PLATTSBURG	Local Government	Clinton	PLATTSBURG	TR TO LITTLE PLATTE RIVER
Binder Community Lake Dam	MO30051	MO DEPT OF CONSERVATION	State	Cole	JEFFERSON CITY	DICKERSON CR
Hough Park Dam	MO30022	DEPT OF PARKS & REC	Local Government	Cole	JEFFERSON CITY	TR MOREAU RIVER
City Park Lake Dam	MO30588	CITY OF SULLIVAN	Local Government	Crawford	SULLIVAN	TRIBUTARY TO STATER CREEK
Grindstone Lmc F-30	MO12113	WILLIAM F. TUCKER	Local Government	Daviess	SANTA ROSA	TR-LAZY CREEK
Buffalo Bill Dam	MO12201	MO DEPT OF CONSERVATION	State	DeKalb	PATTONSBURG	TRIB WEST FORK LOST CREEK
Cameron #3 Dam	MO10170	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TR-GRINDSTONE CREEK
Cameron City Reservoir #1 Dam	MO10042	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Cameron Reservoir #2 Dam	MO10169	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-26	MO50089	GRNSTN-LST-MDY WRSD SBDS	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-39	MO10299	GRNDSTN-LST-MDY WRSD SBD	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam B-21	MO10310	GRNSN-LS-MD WRSD SBDISTR	Local Government	DeKalb	PATTONSBURG	TR-WEST FORK CREEK
King Lake Dam	MO10384	MO DEPT OF CONSERVATION	Local Government	DeKalb	WEATHERBY	LOST CREEK
Maysville New City Dam	MO12375	CITY OF MAYSVILLE	Local Government	DeKalb		
Maysville New Reservoir Dam	MO10670	CITY OF MAYSVILLE	Local Government	DeKalb	MAYSVILLE	TR TO WEST FORK LOST CREEK
Pony Express Lake Dam	MO10171	MO DEPT OF CONSERVATION	State	DeKalb	SANTA ROSA	TR-WEST FORK LOST CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Indian Trail Fish Hatchery Lake Dam	MO30054	MO DEPT OF CONSERVATION	State	Dent	SLIGO	CROOKED CREEK
Port Hudson Lake Dam	MO31981	MO DEPT OF CONSERVATION	State	Franklin	GERALD	CEDAR FORK
King City New Reservoir Dam	MO10078	KING CITY,MISSOURI	Local Government	Gentry	SANTA ROSA	TR-WILLOW CREEK
Limpp Lake Dam	MO10101	MO DEPT OF CONSERVATION	State	Gentry	UNION STAR	TR-THIRD FORK PLATTE RIVER
Middle Fork Water Company Dam	MO40173		Public Utility	Gentry	DARLINGTON	LINN CREEK
Fellows Lake Dam	MO20036	CITY OF SPRINGFIELD,MO	Local Government	Greene	SPRINGFIELD	LITTLE SAC RIVER
Lake Springfield Dam	MO20023	SPRINGFIELD CITY UTILIT.	Local Government	Greene	BATTLEFIELD	JAMES RIVER
Rainbow Lake Dam	MO20394	PAUL OLIVE	State	Greene	ALDRICH	TR-SIMS BR N DRY SAC RIVER
Bethany City Reservoir Dam	MO10051	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO EAST FORK BIG CK
City of Bethany Dam	MO10071	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO WEST FORK BIG CK
Panther Creek C-2	MO10614	JACK FINE HARR.S&W CDIST	Local Government	Harrison	MOUNT MORIAH	PANTHER CREEK
West Fork of Big Creek C-1 Dam	MO12370	HARRISON COUNTY	Local Government	Harrison	BETHANY	LITTLE CREEK
Frank Milne Dam (Dry)	MO11029	MO DEPT OF CONSERVATION	State	Holt	ST JOSEPH	WHALES CREEK
Fayette New City Lake Dam	MO10130	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR-ADAMS FORK
New Horticulture Farm Dam	MO10790	UNIV MO-COLUMBIA	State	Howard	FRANKLIN	TR COTTONWOOD CREEK
Reservoir Dam	MO10001	UNIV.MO/COLUMBIA	State	Howard	FRANKLIN	COTTONWOOD CREEK
Rogers Lake Dam	MO10370	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR ADAMS FORK
Sims Valley Community Lake Dam	MO30055	MO DEPT OF CONSERVATION	State	Howell	HUTTON VALEY	TR ELEVEN POINT RIVER
Shepard Mountain Dam	MO30324	CITY OF IRONTON	Local Government	Iron	ARCADIA	TR-STOUTS CREEK
Adams Dairy Parkway Dam	MO20793		Local Government	Jackson	GRAIN VALLEY	TRIB BLUE BRANCH
Lake Jacomo Dam	MO10045	JACKSON COUNTY	Local Government	Jackson	LEES SUMMIT	EAST FORK LITTLE BLUE RIVER.
Lone Jack Lake Dam	MO20768	MO DEPT OF CONSERVATION	State	Jackson	LONEJACK	TRIB TO THE SNI-A-BAR
Prairie Hollow Lake Dam	MO20777	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	BIG CREEK TRIBUTARY
Prairie Lee Lake Dam	MO10044	JACKSON COPARKS & REC	Local Government	Jackson	BLUE SPRINGS	EAST FORK LITTLE BLUE RIVER
Reed Area No 3	MO20032	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	TR BIG CREEK
Tarsney Lake Dam	MO20136	JACKSON CO. PUBLIC WORKS	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Wood Lake Dam	MO20135	CITY OF TARSNEY LAKES	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Pine Lake Dam	MO30447	MO STATE HWY COMMISSION	State	Jefferson	IMPERIAL	TR-ROCK CREEK
E.Br So Fk Blackwater B-19	MO20438	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS	TR-E.BR SO FK.BLACKWATER
E.Br So Fk Blackwater E-24	MO50228	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS, M	TR-E.BR.SO.FK.BLACKWATER
Holden New City Reservoir	MO20532	CITY OF HOLDEN	Local Government	Johnson	KINGSVILLE	TRIB SOUTH FORK BLACKWATER
Holden Reservoir Dam West	MO20194	CITY OF HOLDEN	Local Government	Johnson	HOLDEN	TR-PIN OAK CREEK
Pertle Springs Dam	MO20044	CENTRAL MO STATE COLLEGE	State	Johnson	WARRENSBURG	TR-EAST FORK POST OAK CREEK
Henry Sever Dam	MO10110	MO DEPT OF CONSERVATION	State	Knox	NEWARK	MEYERS BRANCH
Ford Lake Dam	MO11225	LAFAYETTE SOIL & WATER	Local Government	Lafayette	LEXINGTON	TR EAST FORK SNI-A-BAR CREEK
Little Sni-A-Bar #21	MO12103	LITTLE SNI-A-BAR WATERSHED	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #22	MO11970	LITTLE SNI-A-BAR WATERSHED DIS	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #23	MO11235	LAF SOIL&WTR CONS DIST	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Odessa City Lake Dam	MO20042	CITY OF ODESSA	Local Government	Lafayette	WELLINGTON	TR-EAST FORK SNI-A-BAR CREEK
Wellington Nap C-21	MO10284	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Wellington Nap C-22	MO11228	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR TO MISSOURI RIVER
Wellington Nap C-23	MO10283	LAFAYETTE SOIL & WATER	Local Government	Lafayette	CAMDEN	TR MISSOURI RIVER
Wellington Nap D-21a	MO12000	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington-Nap Wtrshd F-21 Dam	MO10282	WLNGTN-NAP WRSD SUBDISTR	Local Government	Lafayette	NAPOLEON	TR TO HICKLIN BR
Buck-Doe Run Watershed Structure #27a	MO11333	BUCK DOE RUN WSD SUBDST	Local Government	Lewis	CANTON	ARTESIAN BRANCH
City of Lewistown Dam	MO10349	CITY OF LEWISTOWN	Local Government	Lewis	TAYLOR	TR-MIDDLE FABIUS RIVER
Deer Ridge Community Lake Dam	MO10109	MO DEPT OF CONSERVATION	State	Lewis	MONTICELLO	TR-NORTH FABIUS RIVER
La Belle Old City Lake Dam	MO10372	CITY OF LA BELLE	Local Government	Lewis	STEFFENVILLE	TR TROUBLESOME CREEK
Clarence Cannon #15	MO11309	LINCOLN CO SOIL&WATER D	Local Government	Lincoln	ELSBERRY	BRYANTS CREEK
Lake Lincoln Dam	MO10215	MO. DNR PARKS	State	Lincoln	TROY	DRY BRANCH SUGAR CREEK
Lost Cr Pilot Watershed Dam F-4	MO50335	ROBERT PIRTLE	Local Government	Lincoln	ELSBERRY	TR-LOST CREEK
Lost Creek #1	MO10212	LAMMERT FARMS LP	Local Government	Lincoln	ELSBERRY	LOST CREEK
Lost Creek #2	MO10216	LOST CREEK WTRSD SUBDST	Local Government	Lincoln	NEW HOPE	TR-LOST CREEK
Shady Eighty Ranch Lake Dam	MO11306	MO. DNR PARKS	State	Lincoln	MOSCOW MILLS	TR-SUGAR CREEK
White Lake Dam	MO12220	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	MILL CREEK TRIBUTARY
White Memorial Area Sec-16 Lake Dam	MO11286	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	TR-LITTLE SANDY CREEK
Brookfield Reservoir Dam	MO10183	CITY OF BROOKFIELD	Local Government	Linn	BROOKFIELD	WEST YELLOW CREEK-OFFSTREAM
Bucklin City Lake Dam	MO10056	CITY OF BUCKLIN,MO	Local Government	Linn	KEYTESVILLE	TR-VAN DORSEN CREEK
Linneus Lake Dam	MO10437	CITY OF LINNEUS	Local Government	Linn	LINNEUS	TR-LOCUST CREEK
Marceline City Reservoir Dam	MO10119	CITY OF MARCELINE,MO	Local Government	Linn	KEYTESVILLE	CLARKS CREEK
Santa Fe Country Club	MO10765	CITY OF MARCELINE	Local Government	Linn	MARCELINE	TR-EAST YELLOW CREEK
Indian Creek Community Dam	MO12221	MO DEPT OF CONSERVATION	State	Livingston	FARMERSVILLE	INDIAN CREEK (TRIBUTARY)
Macon Lake Dam	MO10153	CITY OF MACON	Local Government	Macon	MACON	DUCK CREEK
New Cambria Lake Dam	MO10387	CITY OF NEW CAMBRIA	Local Government	Macon	NEW CAMBRIA	TR CHARITON RIVER
Southwest City Rc&D Structure E-1	MO20510	MCDON CSW CONS DIST SWC	Local Government	McDonald	SOUTHWEST CITY	TR-HONEY CREEK
Lake Paho Dam	MO10108	MO DEPT OF CONSERVATION	State	Mercer	SPIKARD	WEST MUDDY CREEK
Manito Dam	MO31853	MO DEPT OF CONSERVATION	State	Moniteau	FORTUNA	LITTLE RICHLAND CREEK
Lake Tom Sawyer Dam	MO10058	MARK TWAIN STATE PARK	State	Monroe	FLORIDA	TR-SALT RIVER
Monroe City South Lake Dam	MO10538	CITY OF MONROE	Local Government	Monroe	STOUTSVILLE	TR.TO LITTLE INDIAN CREEK
Wellsville Lake Dam	MO10947	MO DEPT OF CONSERVATION	State	Montgomery	MINEOLA	TR-LITTLE LOUTRE CREEK
Hickory Creek Watershed Structure H- 1a	MO51152	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 2a	MO51159	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 9a	MO51148	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 10d	MO51150	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 11	MO51149	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Lost Creek B-2	MO20730	LOST CREEK WATERSHED S.D	Local Government	Newton	RACINE	LOST CREEK
Lost Creek D-1	MO20731	NEWTON CO.SOIL CON. DIST	Local Government	Newton	SENECA	MCDOUGLE CREEK
Lost Creek E-1	MO20511	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek F-3	MO20514	LOST CK WATERSHED SUBDIS	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-1	MO20512	LOST CREEK WRSD SUBDIST	Local Government	Newton	SENECA	TR-LOST CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Lost Creek Watershed Dam F-2	MO20513	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Site A-1	MO20781	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
Lost Creek Watershed Site C-2	MO20782	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
102 Riv Trib Wtrshd Strctr Lt-36	MO11258	102 RIV TRIB WRSD SUBDST	Local Government	Nodaway	ARKOE	TR-102 RIVER
102 River Tributaries Dam C-5	MO10996	102 RIV TRIB WRSD SUBDIS	Local Government	Nodaway	MARYVILLE	CANAL BRANCH 102 RIVER
Mozingo Creek Dam	MO12277	CITY OF MARYVILLE	Local Government	Nodaway	MARYVILLE	MOZINGO CREEK
Nodaway Lake Dam	MO10178	MO DEPT OF CONSERVATION	State	Nodaway	MARYVILLE	TR-CANAL BRANCH
Ben Branch Dam	MO31844	MO DEPT OF CONSERVATION	State	Osage	LUYSTOWN	BEN BRANCH
Perry County Comm. Lake Dam	MO30813	MO DEPT OF CONSERVATION	State	Perry	SAINT MARYS	TR-SOUTH FORK SALINE CR
Port Perry Dam	MO30030		State	Perry	SILVER LAKE	TR NATIONS CREEK
Spring Fork Lake Dam	MO30152	CITY OF SEDALIA WATER DP	Local Government	Pettis	SEDALIA	CHEESE CK
Windsor Farrington Park Lake Dam	MO20034	CITY OF WINDSOR	Local Government	Pettis	WINDSOR	TR-ELM BRANCH
William E. Towell Dam	MO30090	MO DEPT OF CONSERVATION	State	Phelps	DILLON	TRIBUTARY OF BOUBEUSE RIVER
Bowling Green Dam #1	MO10262		Local Government	Pike	BOWLING GREEN	TRIBUTARY TO NOIX CREEK
Bowling Green Dam #2	MO12195	CITY OF BOWLING GREEN	Local Government	Pike	BOWLING GREEN	TR BUCKNER HOLLOW
Old Bowling Green Reservoir Dam	MO10263	CITY OF BOWLING GREEN	Local Government	Pike	LOUISIANA	TR-BUCKNER HOLLOW-NOIX CREEK
International Airport Dam	MO10661	CITY OF KANSAS CITY MO	Local Government	Platte	PLATTE CITY	TR TODD CREEK
Unionville Old City Lake Dam	MO10152	UNIONVILLE,MO	Local Government	Putnam	UNIONVILLE	TR-BLACKBIRD CREEK
Bear Creek Dam	MO10977	CITY OF HANNIBAL	Local Government	Ralls	HANNIBAL	BEAR CREEK
Perry City Dam - Lower	MO10675	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH LICK CREEK
Perry City Dam No. 2	MO10980	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH
Higbee Lake Dam	MO10222	MARSHALL BAKER	Local Government	Randolph	BURTON	SALT FK BONNE FEMME CREEK
Rothwell Lake Dam	MO10004	MOBERLY PARKS & RECREATN	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Thomas Hill Reservoir Dam	MO10134	ASSOCIATED ELECTRIC CORP	Public Utility	Randolph	THOMAS HILL	MIDDLE FORK CHARITON RIVER
Water Works Lake Dam	MO10006	MOBERLY-PARKS&RECREATION	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Lawson City Lake Dam	MO10147	CITY OF LAWSON	Local Government	Ray	ELMIRA	BRUSHY CREEK
Ray County Lake Dam	MO10098	RAY COUNTY COURT	Local Government	Ray	HODGE	TR-WEST FORK CROOKED RIVER
Richmond Schools Dam	MO10588	RICHMOND SCHOOL DIST R16	Local Government	Ray	HENRIETTA	LICK CREEK
Willow Creek Wtrshd Site A-1	MO11084	WILLOW CREEK WTRSD SUBDS	Local Government	Ray	HENRIETTA	WILLOW CREEK
Taum Sauk Ps Lower	MO30041	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Taum Sauk Ps Upper	MO30040	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Fourche Creek Wtrshd No. 7	MO31408	RIPLEY SOIL/WATER CONSER	Local Government	Ripley	POCAHONTAS ARK	EAST FORK FOURCHE CREEK
Upper Little Black A-2	MO31938	UPPER LITTLE BLACK WATERSHED SUBDISTRICT	Local Government	Ripley	GRANDIN	BEAVER DAM CREEK
Upper Little Black A-7 Dam	MO31829	UPPER LITTLE BLACK SUBD	Local Government	Ripley	GRANDIN	LITTLE BLACK
Upper Little Black D-2	MO31899	UPPER L.BLACK SUBDIST.	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Upper Little Black D-8 Dam	MO31861	DR. MICHAEL SPEZIA	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Van Meter Dam	MO10658	MO. DNR PARKS	State	Saline	MIAMI	TR MISSOURI RIVER
Lancaster City Dam	MO10851	CITY OF LANCASTER	Local Government	Schuyler	LANCASTER	NO.FORK/MIDDLE FAUBIUS RIVER
Queen City Reservoir Dam	MO10186	QUEEN CITY,MO	Local Government	Schuyler	GREENTOP	#NAME?
Memphis Lake Dam	MO10217		Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Memphis Reservoir Dam	MO10163	CITY OF MEMPHIS	Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Caney Basin Dam	MO40070	LITTLE RVR DRAINAGE DIST	Local Government	Scott	ORAN	CANEY CREEK
Tywappity Community Lake Dam	MO40006	MO DEPT OF CONSERVATION	State	Scott	KELSO	HINDMAN CREEK
Clarence City New Lake Dam	MO10608	CITY OF CLARENCE	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Clarence City Old Lake	MO10609	CITY OF CLARENCE,MO	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Shelbina Lake Dam	MO10057	CITY OF SHELBINA	Local Government	Shelby	FLORIDA	TR TO SALT RIVER
Shelbyville Lake Dam	MO10028	CITY OF SHELBYVILLE	Local Government	Shelby	SHELBYVILLE	TR-BLACK CREEK
August A Busch Lake #16 Dam	MO10089	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CR
August A Busch Lake #51 Dam	MO10093	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR SCHOTE CREEK
August A Busch Lake #570 Dam	MO10095	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-DARDENNE CR
Busch Wildlife #35	MO10092	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CREEK
Busch Wildlife #37 Dam	MO10088	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-KRAUT RUN
Sioux Power Plant Dam	MO40160		Public Utility	St. Charles	PORTAGE DES SIOUX	T MISSISSIPPI
Stergen Lake Dam	MO30606	DESPENA STERGEN	State	St. Charles	FEMME OSAGE	TR-FEMME OSAGE CREEK
Univ Mo Exp Farm Dam- Mononame 207	MO10643	MO DEPT OF CONSERVATION	State	St. Charles	WELDON SPRING	EAST BRANCH OF CROOKED CREEK
H&S Hill Top Lake Dam	MO31189		State	St. Francois	BELLEFONTAME	TR-BIG RIVER
Lakeview Park Dam	MO30288	CITY OF BONNE TERRE	Local Government	St. Francois	BONNE TERRE	TURKEY CREEK
St. Joe State Park Dam	MO30277	MO. DNR PARKS	State	St. Francois	FLAT RIVER	SHAW BRANCH-FLAT RIVER
Bee Tree Lake Dam	MO31378	ST. LOUIS COUNTY	Local Government	St. Louis	HERCULANEUM	TR TO MERAMEC RIVER
City of Fenton Dam #1	MO40138		Local Government	St. Louis	FENTON	
City Place Dam	MO31914	CITY OF CREVE COEUR	Local Government	St. Louis	CREVE COEUR	TR CREVE COEUR CREEK
Stacy Park Resevoir Dam	MO31658	CITY OF ST. LOUIS	Local Government	St. Louis	OLIVETTE	RIVER DES PERES
Duck Creek State Wildlife Refuge No 2	MO40093	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek State Wildlife Refuge No 3	MO40094	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek-State Wildlife Refuge-# 1	MO40063	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	CASTOR RIVER
Southwest Rc & D # 1 Dam	MO20509	CITY OF CRANE	Local Government	Stone	CRANE	TR-CRANE CREEK
Elmwood City Lake Dam	MO10240	CITY OF MILAN	Local Government	Sullivan	MILAN	ELMWOOD BRANCH
Sears Community Lake Dam	MO10503	MO DEPT OF CONSERVATION	State	Sullivan	MILAN	TR-EAST LOCUST CREEK
Ozark Beach	MO30088	Empire District Electric Company	Public Utility	Taney	Forsyth	White River
Austin Community Lake Dam	MO30074	MO DEPT OF CONSERVATION	State	Texas	MANES	TR-BEAVER CREEK
Izaak Walton Lake Dam	MO20048	CITY OF NEVADA	Local Government	Vernon	NEVADA	TR TO WHITE BRANCH
Marthasville Mv-5 Dam	MO40111	CITY OF MARTHASVILLE	Local Government	Warren	MARTHASVILLE	TRIB TO TUQUE CREEK
Casey Lake Dam	MO30695	CASEY WOJCIECHOWSKI	State	Washington	LEADWOOD	TR-CLEAR CREEK
Lac Shayne Dam	MO31835	TERRE DU LAC POA	Local Government	Washington	TERRE DU LAC	POND CREEK
Lake Apache Dam	MO30703	CITY OF IRONDALE	Local Government	Washington	IRONDALE	TR DRY CREEK
Eagle Sky Lake Dam	MO30007	CLAUDE KENNEDY	State	Wayne	PATTERSON	CAMP CREEK
Platte River Trib Watershed Dam 3-B	MO11054	PLATTE RVR TR WTSH DIST.	Local Government	Worth	SHERIDAN	TR-PLATTE RIVER
Dam Name	**NID ID**	**Owner Names**	**Owner Types**	**County**	**City**	**River or Stream Name**
Forest Lake Dam	MO10128	CITY OF KIRKSVILLE	Local Government	Adair	KIRKSVILLE	CHARITON RIVER
Savannah City Reservoir Dam	MO10038	CITY OF SAVANNAH	Local Government	Andrew	AMAZONIA	MACE CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Missouri Power and Light Dam	MO10065	CITY OF MEXICO	Local Government	Audrain	MEXICO	TR-SOUTH FORK OF SALT RIVER
Lamar Lake Dam	MO20002	CITY OF LAMAR	Local Government	Barton	LAMAR	TR TO NORTH FORK SPRING RIVER
Adrian Resevoir Dam	MO20005	CITY OF ADRIAN	Local Government	Bates	URICH	TR-BIG DEER CREEK
Appleton City Lake Dam	MO20047	CITY OF APPLETON	Local Government	Bates	TABERVILLE	TR-PANTHER CREEK
Drexel Lake Dam	MO20046	CITY OF DREXEL	Local Government	Bates	DREXEL	NORTH SUGAR CREEK
Callahan Creek A-1	MO11646	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	CALLAHAN CR
Callahan Creek C-2	MO11774	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	BARCLAY BR
Columbia Mum. Golf Course Dam	MO11068	COLUMBIA PARK & REC DEPT	Local Government	Boone	COLUMBIA	TR-HARMONY CREEK
Columbia Mun Golf Course Lower L. Dam	MO10895	CITY OF COLUMBIA	Local Government	Boone	MCBAINE	TRIBUTARY TO HARMONY CREEK
Moores Lake Dam	MO11173	CITY OF COLUMBIA	Local Government	Boone	COLUMBIA	TR-BEAR CREEK
Turkey Farm Lake Dam	MO10552	UNIVERSITY OF MISSOURI	State	Boone	JEFFERSON CITY	TR LITTLE CEDAR CREEK
Univ of Mo-R1 Dam	MO11606	UNIVERSITY OF MISSOURI	State	Boone	WILTON	TR GANS CREEK
Belcher Branch Lake Dam	MO12290	MO DEPT OF CONSERVATION	State	Buchanan	FAUCETT	TR-BELCHER BRANCH
Dearborn Reservoir Dam	MO10426	CITY OF DEARBORN	Local Government	Buchanan	DEARBORN @	TR-BEE CREEK
City of Breckenridge Dam	MO10645	CITY OF BRECKENRIDGE	Local Government	Caldwell	BEDFORD	TR-PANTHER CREEK
Hamilton City Water Plant Dam	MO10261	MAYOR DANNY ALEXANDER	Local Government	Caldwell	HAMILTON	TOM CREEK
Baumgartner Lake Dam	MO12278	JAMES BAUMGARTNER	State	Callaway	HOLTS SUMMIT	CASON BRANCH
Little Dixie Lake Dam	MO10888	MO DEPT OF CONSERVATION	State	Callaway	MILLERSBURG	OWL CREEK
Whetstone Creek Big Lake Dam	MO10876	MO DEPT OF CONSERVATION	State	Callaway	MINEOLA	TR WHETSTONE CREEK
City of Cape Girardeau Dam	MO40109		Local Government	Cape Girardeau		
Lake Boutin Dam	MO40008	MO. DNR PARKS	State	Cape Girardeau	NEELYS LANDING	TR-FLORA CREEK
Lake Girardeau Dam	MO30066	MO DEPT OF CONSERVATION	State	Cape Girardeau	DONGOLA	TR-CROOKED CREEK
Big Creek-Hurricane Creek S- 12	MO50809	BIG CREEK WATERSHED SUBDISTRIC	Local Government	Carroll	NONE	TR-BIG CREEK
City Lake Dam	MO20314	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Harrisonville City Lake Dam	MO20077	CITY OF HARRISONVILLE	Local Government	Cass	PLEASANT HILL	TR MIDDLE BIG CREEK
Lake Luna Dam	MO20076	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Peculiar City Resevoir Dam	MO20305	CITY OF PECULIAR	Local Government	Cass	HARRISONVILLE	TR-WOLF CREEK BRANCH
Pleasant Hill Lake Dam	MO20004	CITY OF PLEASANT HILL	Local Government	Cass	PLEASANT HILL	TR-WILSON CREEK
Marceline New Reservoir Dam	MO12127	CITY OF MARCELINE	Local Government	Chariton	ROTHVILLE	SLATER BRANCH
Fox Valley Dam	MO12197	MO DEPT OF CONSERVATION	State	Clark	KAHOKA	FOX CREEK
Wyaconda City Dam	MO10009	CITY OF WYACONDA	Local Government	Clark	MEDILL	TR-SOUTH WYACONDA RIVER
Watkins Mill State Park Dam	MO10011	MO. DNR PARKS	State	Clay	PRATHERSVILLE	TR-WILLIAMS CREEK
Plattsburg Old Reservoir Dam	MO10267	CITY OF PLATTSBURG	Local Government	Clinton	PLATTSBURG	TR TO LITTLE PLATTE RIVER
Binder Community Lake Dam	MO30051	MO DEPT OF CONSERVATION	State	Cole	JEFFERSON CITY	DICKERSON CR
Hough Park Dam	MO30022	DEPT OF PARKS & REC	Local Government	Cole	JEFFERSON CITY	TR MOREAU RIVER
City Park Lake Dam	MO30588	CITY OF SULLIVAN	Local Government	Crawford	SULLIVAN	TRIBUTARY TO STATER CREEK
Grindstone Lmc F-30	MO12113	WILLIAM F. TUCKER	Local Government	Daviess	SANTA ROSA	TR-LAZY CREEK
Buffalo Bill Dam	MO12201	MO DEPT OF CONSERVATION	State	DeKalb	PATTONSBURG	TRIB WEST FORK LOST CREEK
Cameron #3 Dam	MO10170	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TR-GRINDSTONE CREEK
Cameron City Reservoir #1 Dam	MO10042	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Cameron Reservoir #2 Dam	MO10169	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-26	MO50089	GRNSTN-LST-MDY WRSD SBDS	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-39	MO10299	GRNDSTN-LST-MDY WRSD SBD	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam B-21	MO10310	GRNSN-LS-MD WRSD SBDISTR	Local Government	DeKalb	PATTONSBURG	TR-WEST FORK CREEK
King Lake Dam	MO10384	MO DEPT OF CONSERVATION	Local Government	DeKalb	WEATHERBY	LOST CREEK
Maysville New City Dam	MO12375	CITY OF MAYSVILLE	Local Government	DeKalb		
Maysville New Reservoir Dam	MO10670	CITY OF MAYSVILLE	Local Government	DeKalb	MAYSVILLE	TR TO WEST FORK LOST CREEK
Pony Express Lake Dam	MO10171	MO DEPT OF CONSERVATION	State	DeKalb	SANTA ROSA	TR-WEST FORK LOST CREEK
Indian Trail Fish Hatchery Lake Dam	MO30054	MO DEPT OF CONSERVATION	State	Dent	SLIGO	CROOKED CREEK
Port Hudson Lake Dam	MO31981	MO DEPT OF CONSERVATION	State	Franklin	GERALD	CEDAR FORK
King City New Reservoir Dam	MO10078	KING CITY,MISSOURI	Local Government	Gentry	SANTA ROSA	TR-WILLOW CREEK
Limpp Lake Dam	MO10101	MO DEPT OF CONSERVATION	State	Gentry	UNION STAR	TR-THIRD FORK PLATTE RIVER
Middle Fork Water Company Dam	MO40173		Public Utility	Gentry	DARLINGTON	LINN CREEK
Fellows Lake Dam	MO20036	CITY OF SPRINGFIELD,MO	Local Government	Greene	SPRINGFIELD	LITTLE SAC RIVER
Lake Springfield Dam	MO20023	SPRINGFIELD CITY UTILIT.	Local Government	Greene	BATTLEFIELD	JAMES RIVER
Rainbow Lake Dam	MO20394	PAUL OLIVE	State	Greene	ALDRICH	TR-SIMS BR N DRY SAC RIVER
Bethany City Reservoir Dam	MO10051	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO EAST FORK BIG CK
City of Bethany Dam	MO10071	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO WEST FORK BIG CK
Panther Creek C-2	MO10614	JACK FINE HARR.S&W CDIST	Local Government	Harrison	MOUNT MORIAH	PANTHER CREEK
West Fork of Big Creek C-1 Dam	MO12370	HARRISON COUNTY	Local Government	Harrison	BETHANY	LITTLE CREEK
Frank Milne Dam (Dry)	MO11029	MO DEPT OF CONSERVATION	State	Holt	ST JOSEPH	WHALES CREEK
Fayette New City Lake Dam	MO10130	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR-ADAMS FORK
New Horticulture Farm Dam	MO10790	UNIV MO-COLUMBIA	State	Howard	FRANKLIN	TR COTTONWOOD CREEK
Reservoir Dam	MO10001	UNIV.MO/COLUMBIA	State	Howard	FRANKLIN	COTTONWOOD CREEK
Rogers Lake Dam	MO10370	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR ADAMS FORK
Sims Valley Community Lake Dam	MO30055	MO DEPT OF CONSERVATION	State	Howell	HUTTON VALEY	TR ELEVEN POINT RIVER
Shepard Mountain Dam	MO30324	CITY OF IRONTON	Local Government	Iron	ARCADIA	TR-STOUTS CREEK
Adams Dairy Parkway Dam	MO20793		Local Government	Jackson	GRAIN VALLEY	TRIB BLUE BRANCH
Lake Jacomo Dam	MO10045	JACKSON COUNTY	Local Government	Jackson	LEES SUMMIT	EAST FORK LITTLE BLUE RIVER.
Lone Jack Lake Dam	MO20768	MO DEPT OF CONSERVATION	State	Jackson	LONEJACK	TRIB TO THE SNI-A-BAR
Prairie Hollow Lake Dam	MO20777	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	BIG CREEK TRIBUTARY
Prairie Lee Lake Dam	MO10044	JACKSON COPARKS & REC	Local Government	Jackson	BLUE SPRINGS	EAST FORK LITTLE BLUE RIVER
Reed Area No 3	MO20032	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	TR BIG CREEK
Tarsney Lake Dam	MO20136	JACKSON CO. PUBLIC WORKS	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Wood Lake Dam	MO20135	CITY OF TARSNEY LAKES	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Pine Lake Dam	MO30447	MO STATE HWY COMMISSION	State	Jefferson	IMPERIAL	TR-ROCK CREEK
E.Br So Fk Blackwater B-19	MO20438	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS	TR-E.BR SO FK.BLACKWATER
E.Br So Fk Blackwater E-24	MO50228	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS, M	TR-E.BR.SO.FK.BLACKWATER

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Holden New City Reservoir	MO20532	CITY OF HOLDEN	Local Government	Johnson	KINGSVILLE	TRIB SOUTH FORK BLACKWATER
Holden Reservoir Dam West	MO20194	CITY OF HOLDEN	Local Government	Johnson	HOLDEN	TR-PIN OAK CREEK
Pertle Springs Dam	MO20044	CENTRAL MO STATE COLLEGE	State	Johnson	WARRENSBURG	TR-EAST FORK POST OAK CREEK
Henry Sever Dam	MO10110	MO DEPT OF CONSERVATION	State	Knox	NEWARK	MEYERS BRANCH
Ford Lake Dam	MO11225	LAFAYETTE SOIL & WATER	Local Government	Lafayette	LEXINGTON	TR EAST FORK SNI-A-BAR CREEK
Little Sni-A-Bar #21	MO12103	LITTLE SNI-A-BAR WATERSHED	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #22	MO11970	LITTLE SNI-A-BAR WATERSHED DIS	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #23	MO11235	LAF SOIL&WTR CONS DIST	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Odessa City Lake Dam	MO20042	CITY OF ODESSA	Local Government	Lafayette	WELLINGTON	TR-EAST FORK SNI-A-BAR CREEK
Wellington Nap C-21	MO10284	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington Nap C-22	MO11228	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR TO MISSOURI RIVER
Wellington Nap C-23	MO10283	LAFAYETTE SOIL & WATER	Local Government	Lafayette	CAMDEN	TR MISSOURI RIVER
Wellington Nap D-21a	MO12000	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington-Nap Wtrshd F-21 Dam	MO10282	WLNGTN-NAP WRSD SUBDISTR	Local Government	Lafayette	NAPOLEON	TR TO HICKLIN BR
Buck-Doe Run Watershed Structure #27a	MO11333	BUCK DOE RUN WSD SUBDST	Local Government	Lewis	CANTON	ARTESIAN BRANCH
City of Lewistown Dam	MO10349	CITY OF LEWISTOWN	Local Government	Lewis	TAYLOR	TR-MIDDLE FABIUS RIVER
Deer Ridge Community Lake Dam	MO10109	MO DEPT OF CONSERVATION	State	Lewis	MONTICELLO	TR-NORTH FABIUS RIVER
La Belle Old City Lake Dam	MO10372	CITY OF LA BELLE	Local Government	Lewis	STEFFENVILLE	TR TROUBLESOME CREEK
Clarence Cannon #15	MO11309	LINCOLN CO SOIL&WATER D	Local Government	Lincoln	ELSBERRY	BRYANTS CREEK
Lake Lincoln Dam	MO10215	MO. DNR PARKS	State	Lincoln	TROY	DRY BRANCH SUGAR CREEK
Lost Cr Pilot Watershed Dam F-4	MO50335	ROBERT PIRTLE	Local Government	Lincoln	ELSBERRY	TR-LOST CREEK
Lost Creek #1	MO10212	LAMMERT FARMS LP	Local Government	Lincoln	ELSBERRY	LOST CREEK
Lost Creek #2	MO10216	LOST CREEK WTRSD SUBDST	Local Government	Lincoln	NEW HOPE	TR-LOST CREEK
Shady Eighty Ranch Lake Dam	MO11306	MO. DNR PARKS	State	Lincoln	MOSCOW MILLS	TR-SUGAR CREEK
White Lake Dam	MO12220	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	MILL CREEK TRIBUTARY
White Memorial Area Sec-16 Lake Dam	MO11286	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	TR-LITTLE SANDY CREEK
Brookfield Reservoir Dam	MO10183	CITY OF BROOKFIELD	Local Government	Linn	BROOKFIELD	WEST YELLOW CREEK-OFFSTREAM
Bucklin City Lake Dam	MO10056	CITY OF BUCKLIN,MO	Local Government	Linn	KEYTESVILLE	TR-VAN DORSEN CREEK
Linneus Lake Dam	MO10437	CITY OF LINNEUS	Local Government	Linn	LINNEUS	TR-LOCUST CREEK
Marceline City Reservoir Dam	MO10119	CITY OF MARCELINE,MO	Local Government	Linn	KEYTESVILLE	CLARKS CREEK
Santa Fe Country Club	MO10765	CITY OF MARCELINE	Local Government	Linn	MARCELINE	TR-EAST YELLOW CREEK
Indian Creek Community Dam	MO12221	MO DEPT OF CONSERVATION	State	Livingston	FARMERSVILLE	INDIAN CREEK (TRIBUTARY)
Macon Lake Dam	MO10153	CITY OF MACON	Local Government	Macon	MACON	DUCK CREEK
New Cambria Lake Dam	MO10387	CITY OF NEW CAMBRIA	Local Government	Macon	NEW CAMBRIA	TR CHARITON RIVER
Southwest City Rc&D Structure E-1	MO20510	MCDON CSW CONS DIST SWC	Local Government	McDonald	SOUTHWEST CITY	TR-HONEY CREEK
Lake Paho Dam	MO10108	MO DEPT OF CONSERVATION	State	Mercer	SPIKARD	WEST MUDDY CREEK
Manito Dam	MO31853	MO DEPT OF CONSERVATION	State	Moniteau	FORTUNA	LITTLE RICHLAND CREEK
Lake Tom Sawyer Dam	MO10058	MARK TWAIN STATE PARK	State	Monroe	FLORIDA	TR-SALT RIVER
Monroe City South Lake Dam	MO10538	CITY OF MONROE	Local Government	Monroe	STOUTSVILLE	TR.TO LITTLE INDIAN CREEK
Wellsville Lake Dam	MO10947	MO DEPT OF CONSERVATION	State	Montgomery	MINEOLA	TR-LITTLE LOUTRE CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Hickory Creek Watershed Structure H- 1a	MO51152	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 2a	MO51159	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 9a	MO51148	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 10d	MO51150	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 11	MO51149	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Lost Creek B-2	MO20730	LOST CREEK WATERSHED S.D	Local Government	Newton	RACINE	LOST CREEK
Lost Creek D-1	MO20731	NEWTON CO.SOIL CON. DIST	Local Government	Newton	SENECA	MCDOUGLE CREEK
Lost Creek E-1	MO20511	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek F-3	MO20514	LOST CK WATERSHED SUBDIS	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-1	MO20512	LOST CREEK WRSD SUBDIST	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-2	MO20513	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Site A-1	MO20781	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
Lost Creek Watershed Site C-2	MO20782	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
102 Riv Trib Wtrshd Strctr Lt-36	MO11258	102 RIV TRIB WRSD SUBDST	Local Government	Nodaway	ARKOE	TR-102 RIVER
102 River Tributaries Dam C-5	MO10996	102 RIV TRIB WRSD SUBDIS	Local Government	Nodaway	MARYVILLE	CANAL BRANCH 102 RIVER
Mozingo Creek Dam	MO12277	CITY OF MARYVILLE	Local Government	Nodaway	MARYVILLE	MOZINGO CREEK
Nodaway Lake Dam	MO10178	MO DEPT OF CONSERVATION	State	Nodaway	MARYVILLE	TR-CANAL BRANCH
Ben Branch Dam	MO31844	MO DEPT OF CONSERVATION	State	Osage	LUYSTOWN	BEN BRANCH
Perry County Comm. Lake Dam	MO30813	MO DEPT OF CONSERVATION	State	Perry	SAINT MARYS	TR-SOUTH FORK SALINE CR
Port Perry Dam	MO30030		State	Perry	SILVER LAKE	TR NATIONS CREEK
Spring Fork Lake Dam	MO30152	CITY OF SEDALIA WATER DP	Local Government	Pettis	SEDALIA	CHEESE CK
Windsor Farrington Park Lake Dam	MO20034	CITY OF WINDSOR	Local Government	Pettis	WINDSOR	TR-ELM BRANCH
William E. Towell Dam	MO30090	MO DEPT OF CONSERVATION	State	Phelps	DILLON	TRIBUTARY OF BOUBEUSE RIVER
Bowling Green Dam #1	MO10262		Local Government	Pike	BOWLING GREEN	TRIBUTARY TO NOIX CREEK
Bowling Green Dam #2	MO12195	CITY OF BOWLING GREEN	Local Government	Pike	BOWLING GREEN	TR BUCKNER HOLLOW
Old Bowling Green Reservoir Dam	MO10263	CITY OF BOWLING GREEN	Local Government	Pike	LOUISIANA	TR-BUCKNER HOLLOW-NOIX CREEK
International Airport Dam	MO10661	CITY OF KANSAS CITY MO	Local Government	Platte	PLATTE CITY	TR TODD CREEK
Unionville Old City Lake Dam	MO10152	UNIONVILLE,MO	Local Government	Putnam	UNIONVILLE	TR-BLACKBIRD CREEK
Bear Creek Dam	MO10977	CITY OF HANNIBAL	Local Government	Ralls	HANNIBAL	BEAR CREEK
Perry City Dam - Lower	MO10675	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH LICK CREEK
Perry City Dam No. 2	MO10980	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH
Higbee Lake Dam	MO10222	MARSHALL BAKER	Local Government	Randolph	BURTON	SALT FK BONNE FEMME CREEK
Rothwell Lake Dam	MO10004	MOBERLY PARKS & RECREATN	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Thomas Hill Reservoir Dam	MO10134	ASSOCIATED ELECTRIC CORP	Public Utility	Randolph	THOMAS HILL	MIDDLE FORK CHARITON RIVER
Water Works Lake Dam	MO10006	MOBERLY-PARKS&RECREATION	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Lawson City Lake Dam	MO10147	CITY OF LAWSON	Local Government	Ray	ELMIRA	BRUSHY CREEK
Ray County Lake Dam	MO10098	RAY COUNTY COURT	Local Government	Ray	HODGE	TR-WEST FORK CROOKED RIVER
Richmond Schools Dam	MO10588	RICHMOND SCHOOL DIST R16	Local Government	Ray	HENRIETTA	LICK CREEK
Willow Creek Wtrshd Site A-1	MO11084	WILLOW CREEK WTRSD SUBDS	Local Government	Ray	HENRIETTA	WILLOW CREEK
Taum Sauk Ps Lower	MO30041	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Taum Sauk Ps Upper	MO30040	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Fourche Creek Wtrshd No. 7	MO31408	RIPLEY SOIL/WATER CONSER	Local Government	Ripley	POCAHONTAS ARK	EAST FORK FOURCHE CREEK
Upper Little Black A-2	MO31938	UPPER LITTLE BLACK WATERSHED SUBDISTRICT	Local Government	Ripley	GRANDIN	BEAVER DAM CREEK
Upper Little Black A-7 Dam	MO31829	UPPER LITTLE BLACK SUBD	Local Government	Ripley	GRANDIN	LITTLE BLACK
Upper Little Black D-2	MO31899	UPPER L.BLACK SUBDIST.	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Upper Little Black D-8 Dam	MO31861	DR. MICHAEL SPEZIA	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Van Meter Dam	MO10658	MO. DNR PARKS	State	Saline	MIAMI	TR MISSOURI RIVER
Lancaster City Dam	MO10851	CITY OF LANCASTER	Local Government	Schuyler	LANCASTER	NO.FORK/MIDDLE FAUBIUS RIVER
Queen City Reservoir Dam	MO10186	QUEEN CITY,MO	Local Government	Schuyler	GREENTOP	#NAME?
Memphis Lake Dam	MO10217		Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Memphis Reservoir Dam	MO10163	CITY OF MEMPHIS	Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Caney Basin Dam	MO40070	LITTLE RVR DRAINAGE DIST	Local Government	Scott	ORAN	CANEY CREEK
Tywappity Community Lake Dam	MO40006	MO DEPT OF CONSERVATION	State	Scott	KELSO	HINDMAN CREEK
Clarence City New Lake Dam	MO10608	CITY OF CLARENCE	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Clarence City Old Lake	MO10609	CITY OF CLARENCE,MO	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Shelbina Lake Dam	MO10057	CITY OF SHELBINA	Local Government	Shelby	FLORIDA	TR TO SALT RIVER
Shelbyville Lake Dam	MO10028	CITY OF SHELBYVILLE	Local Government	Shelby	SHELBYVILLE	TR-BLACK CREEK
August A Busch Lake #16 Dam	MO10089	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CR
August A Busch Lake #51 Dam	MO10093	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR SCHOTE CREEK
August A Busch Lake #570 Dam	MO10095	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-DARDENNE CR
Busch Wildlife #35	MO10092	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CREEK
Busch Wildlife #37 Dam	MO10088	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-KRAUT RUN
Sioux Power Plant Dam	MO40160		Public Utility	St. Charles	PORTAGE DES SIOUX	T MISSISSIPPI
Stergen Lake Dam	MO30606	DESPENA STERGEN	State	St. Charles	FEMME OSAGE	TR-FEMME OSAGE CREEK
Univ Mo Exp Farm Dam- Mononame 207	MO10643	MO DEPT OF CONSERVATION	State	St. Charles	WELDON SPRING	EAST BRANCH OF CROOKED CREEK
H&S Hill Top Lake Dam	MO31189		State	St. Francois	BELLEFONTAME	TR-BIG RIVER
Lakeview Park Dam	MO30288	CITY OF BONNE TERRE	Local Government	St. Francois	BONNE TERRE	TURKEY CREEK
St. Joe State Park Dam	MO30277	MO. DNR PARKS	State	St. Francois	FLAT RIVER	SHAW BRANCH-FLAT RIVER
Bee Tree Lake Dam	MO31378	ST. LOUIS COUNTY	Local Government	St. Louis	HERCULANEUM	TR TO MERAMEC RIVER
City of Fenton Dam #1	MO40138		Local Government	St. Louis	FENTON	
City Place Dam	MO31914	CITY OF CREVE COEUR	Local Government	St. Louis	CREVE COEUR	TR CREVE COEUR CREEK
Stacy Park Resevoir Dam	MO31658	CITY OF ST. LOUIS	Local Government	St. Louis	OLIVETTE	RIVER DES PERES
Duck Creek State Wildlife Refuge No 2	MO40093	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek State Wildlife Refuge No 3	MO40094	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek-State Wildlife Refuge-# 1	MO40063	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	CASTOR RIVER
Southwest Rc & D # 1 Dam	MO20509	CITY OF CRANE	Local Government	Stone	CRANE	TR-CRANE CREEK
Elmwood City Lake Dam	MO10240	CITY OF MILAN	Local Government	Sullivan	MILAN	ELMWOOD BRANCH
Sears Community Lake Dam	MO10503	MO DEPT OF CONSERVATION	State	Sullivan	MILAN	TR-EAST LOCUST CREEK
Ozark Beach	MO30088	Empire District Electric Company	Public Utility	Taney	Forsyth	White River
Austin Community Lake Dam	MO30074	MO DEPT OF CONSERVATION	State	Texas	MANES	TR-BEAVER CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Izaak Walton Lake Dam	MO20048	CITY OF NEVADA	Local Government	Vernon	NEVADA	TR TO WHITE BRANCH
Marthasville Mv-5 Dam	MO40111	CITY OF MARTHASVILLE	Local Government	Warren	MARTHASVILLE	TRIB TO TUQUE CREEK
Casey Lake Dam	MO30695	CASEY WOJCIECHOWSKI	State	Washington	LEADWOOD	TR-CLEAR CREEK
Lac Shayne Dam	MO31835	TERRE DU LAC POA	Local Government	Washington	TERRE DU LAC	POND CREEK
Lake Apache Dam	MO30703	CITY OF IRONDALE	Local Government	Washington	IRONDALE	TR DRY CREEK
Eagle Sky Lake Dam	MO30007	CLAUDE KENNEDY	State	Wayne	PATTERSON	CAMP CREEK
Platte River Trib Watershed Dam 3-B	MO11054	PLATTE RVR TR WTSH DIST.	Local Government	Worth	SHERIDAN	TR-PLATTE RIVER
Dam Name	**NID ID**	**Owner Names**	**Owner Types**	**County**	**City**	**River or Stream Name**
Forest Lake Dam	MO10128	CITY OF KIRKSVILLE	Local Government	Adair	KIRKSVILLE	CHARITON RIVER
Savannah City Reservoir Dam	MO10038	CITY OF SAVANNAH	Local Government	Andrew	AMAZONIA	MACE CREEK
Missouri Power and Light Dam	MO10065	CITY OF MEXICO	Local Government	Audrain	MEXICO	TR-SOUTH FORK OF SALT RIVER
Lamar Lake Dam	MO20002	CITY OF LAMAR	Local Government	Barton	LAMAR	TR TO NORTH FORK SPRING RIVER
Adrian Resevoir Dam	MO20005	CITY OF ADRIAN	Local Government	Bates	URICH	TR-BIG DEER CREEK
Appleton City Lake Dam	MO20047	CITY OF APPLETON	Local Government	Bates	TABERVILLE	TR-PANTHER CREEK
Drexel Lake Dam	MO20046	CITY OF DREXEL	Local Government	Bates	DREXEL	NORTH SUGAR CREEK
Callahan Creek A-1	MO11646	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	CALLAHAN CR
Callahan Creek C-2	MO11774	CALLAHAN CR WTRSD SUBDST	Local Government	Boone	MCBAINE	BARCLAY BR
Columbia Mum. Golf Course Dam	MO11068	COLUMBIA PARK & REC DEPT	Local Government	Boone	COLUMBIA	TR-HARMONY CREEK
Columbia Mun Golf Course Lower L. Dam	MO10895	CITY OF COLUMBIA	Local Government	Boone	MCBAINE	TRIBUTARY TO HARMONY CREEK
Moores Lake Dam	MO11173	CITY OF COLUMBIA	Local Government	Boone	COLUMBIA	TR-BEAR CREEK
Turkey Farm Lake Dam	MO10552	UNIVERSITY OF MISSOURI	State	Boone	JEFFERSON CITY	TR LITTLE CEDAR CREEK
Univ of Mo-R1 Dam	MO11606	UNIVERSITY OF MISSOURI	State	Boone	WILTON	TR GANS CREEK
Belcher Branch Lake Dam	MO12290	MO DEPT OF CONSERVATION	State	Buchanan	FAUCETT	TR-BELCHER BRANCH
Dearborn Reservoir Dam	MO10426	CITY OF DEARBORN	Local Government	Buchanan	DEARBORN @	TR-BEE CREEK
City of Breckenridge Dam	MO10645	CITY OF BRECKENRIDGE	Local Government	Caldwell	BEDFORD	TR-PANTHER CREEK
Hamilton City Water Plant Dam	MO10261	MAYOR DANNY ALEXANDER	Local Government	Caldwell	HAMILTON	TOM CREEK
Baumgartner Lake Dam	MO12278	JAMES BAUMGARTNER	State	Callaway	HOLTS SUMMIT	CASON BRANCH
Little Dixie Lake Dam	MO10888	MO DEPT OF CONSERVATION	State	Callaway	MILLERSBURG	OWL CREEK
Whetstone Creek Big Lake Dam	MO10876	MO DEPT OF CONSERVATION	State	Callaway	MINEOLA	TR WHETSTONE CREEK
City of Cape Girardeau Dam	MO40109		Local Government	Cape Girardeau		
Lake Boutin Dam	MO40008	MO. DNR PARKS	State	Cape Girardeau	NEELYS LANDING	TR-FLORA CREEK
Lake Girardeau Dam	MO30066	MO DEPT OF CONSERVATION	State	Cape Girardeau	DONGOLA	TR-CROOKED CREEK
Big Creek-Hurricane Creek S- 12	MO50809	BIG CREEK WATERSHED SUBDISTRIC	Local Government	Carroll	NONE	TR-BIG CREEK
City Lake Dam	MO20314	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Harrisonville City Lake Dam	MO20077	CITY OF HARRISONVILLE	Local Government	Cass	PLEASANT HILL	TR MIDDLE BIG CREEK
Lake Luna Dam	MO20076	CITY OF HARRISONVILLE	Local Government	Cass	HARRISONVILLE	TOWN CREEK
Peculiar City Resevoir Dam	MO20305	CITY OF PECULIAR	Local Government	Cass	HARRISONVILLE	TR-WOLF CREEK BRANCH
Pleasant Hill Lake Dam	MO20004	CITY OF PLEASANT HILL	Local Government	Cass	PLEASANT HILL	TR-WILSON CREEK
Marceline New Reservoir Dam	MO12127	CITY OF MARCELINE	Local Government	Chariton	ROTHVILLE	SLATER BRANCH
Fox Valley Dam	MO12197	MO DEPT OF CONSERVATION	State	Clark	KAHOKA	FOX CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Wyaconda City Dam	MO10009	CITY OF WYACONDA	Local Government	Clark	MEDILL	TR-SOUTH WYACONDA RIVER
Watkins Mill State Park Dam	MO10011	MO. DNR PARKS	State	Clay	PRATHERSVILLE	TR-WILLIAMS CREEK
Plattsburg Old Reservoir Dam	MO10267	CITY OF PLATTSBURG	Local Government	Clinton	PLATTSBURG	TR TO LITTLE PLATTE RIVER
Binder Community Lake Dam	MO30051	MO DEPT OF CONSERVATION	State	Cole	JEFFERSON CITY	DICKERSON CR
Hough Park Dam	MO30022	DEPT OF PARKS & REC	Local Government	Cole	JEFFERSON CITY	TR MOREAU RIVER
City Park Lake Dam	MO30588	CITY OF SULLIVAN	Local Government	Crawford	SULLIVAN	TRIBUTARY TO STATER CREEK
Grindstone Lmc F-30	MO12113	WILLIAM F. TUCKER	Local Government	Daviess	SANTA ROSA	TR-LAZY CREEK
Buffalo Bill Dam	MO12201	MO DEPT OF CONSERVATION	State	DeKalb	PATTONSBURG	TRIB WEST FORK LOST CREEK
Cameron #3 Dam	MO10170	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TR-GRINDSTONE CREEK
Cameron City Reservoir #1 Dam	MO10042	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Cameron Reservoir #2 Dam	MO10169	CITY OF CAMERON	Local Government	DeKalb	CAMERON	TRIBUTARY TO GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-26	MO50089	GRNSTN-LST-MDY WRSD SBDS	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam A-39	MO10299	GRNDSTN-LST-MDY WRSD SBD	Local Government	DeKalb	PATTONSBURG	TR-GRINDSTONE CREEK
Grindstone-Lost-Muddy Watershed Dam B-21	MO10310	GRNSN-LS-MD WRSD SBDISTR	Local Government	DeKalb	PATTONSBURG	TR-WEST FORK CREEK
King Lake Dam	MO10384	MO DEPT OF CONSERVATION	Local Government	DeKalb	WEATHERBY	LOST CREEK
Maysville New City Dam	MO12375	CITY OF MAYSVILLE	Local Government	DeKalb		
Maysville New Reservoir Dam	MO10670	CITY OF MAYSVILLE	Local Government	DeKalb	MAYSVILLE	TR TO WEST FORK LOST CREEK
Pony Express Lake Dam	MO10171	MO DEPT OF CONSERVATION	State	DeKalb	SANTA ROSA	TR-WEST FORK LOST CREEK
Indian Trail Fish Hatchery Lake Dam	MO30054	MO DEPT OF CONSERVATION	State	Dent	SLIGO	CROOKED CREEK
Port Hudson Lake Dam	MO31981	MO DEPT OF CONSERVATION	State	Franklin	GERALD	CEDAR FORK
King City New Reservoir Dam	MO10078	KING CITY,MISSOURI	Local Government	Gentry	SANTA ROSA	TR-WILLOW CREEK
Limpp Lake Dam	MO10101	MO DEPT OF CONSERVATION	State	Gentry	UNION STAR	TR-THIRD FORK PLATTE RIVER
Middle Fork Water Company Dam	MO40173		Public Utility	Gentry	DARLINGTON	LINN CREEK
Fellows Lake Dam	MO20036	CITY OF SPRINGFIELD,MO	Local Government	Greene	SPRINGFIELD	LITTLE SAC RIVER
Lake Springfield Dam	MO20023	SPRINGFIELD CITY UTILIT.	Local Government	Greene	BATTLEFIELD	JAMES RIVER
Rainbow Lake Dam	MO20394	PAUL OLIVE	State	Greene	ALDRICH	TR-SIMS BR N DRY SAC RIVER
Bethany City Reservoir Dam	MO10051	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO EAST FORK BIG CK
City of Bethany Dam	MO10071	CITY OF BETHANY	Local Government	Harrison	BETHANY	TRIBUTARY TO WEST FORK BIG CK
Panther Creek C-2	MO10614	JACK FINE HARR.S&W CDIST	Local Government	Harrison	MOUNT MORIAH	PANTHER CREEK
West Fork of Big Creek C-1 Dam	MO12370	HARRISON COUNTY	Local Government	Harrison	BETHANY	LITTLE CREEK
Frank Milne Dam (Dry)	MO11029	MO DEPT OF CONSERVATION	State	Holt	ST JOSEPH	WHALES CREEK
Fayette New City Lake Dam	MO10130	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR-ADAMS FORK
New Horticulture Farm Dam	MO10790	UNIV MO-COLUMBIA	State	Howard	FRANKLIN	TR COTTONWOOD CREEK
Reservoir Dam	MO10001	UNIV.MO/COLUMBIA	State	Howard	FRANKLIN	COTTONWOOD CREEK
Rogers Lake Dam	MO10370	CITY OF FAYETTE	Local Government	Howard	FAYETTE	TR ADAMS FORK
Sims Valley Community Lake Dam	MO30055	MO DEPT OF CONSERVATION	State	Howell	HUTTON VALEY	TR ELEVEN POINT RIVER
Shepard Mountain Dam	MO30324	CITY OF IRONTON	Local Government	Iron	ARCADIA	TR-STOUTS CREEK
Adams Dairy Parkway Dam	MO20793		Local Government	Jackson	GRAIN VALLEY	TRIB BLUE BRANCH

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Lake Jacomo Dam	MO10045	JACKSON COUNTY	Local Government	Jackson	LEES SUMMIT	EAST FORK LITTLE BLUE RIVER.
Lone Jack Lake Dam	MO20768	MO DEPT OF CONSERVATION	State	Jackson	LONEJACK	TRIB TO THE SNI-A-BAR
Prairie Hollow Lake Dam	MO20777	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	BIG CREEK TRIBUTARY
Prairie Lee Lake Dam	MO10044	JACKSON COPARKS & REC	Local Government	Jackson	BLUE SPRINGS	EAST FORK LITTLE BLUE RIVER
Reed Area No 3	MO20032	MO DEPT OF CONSERVATION	State	Jackson	GREENWOOD	TR BIG CREEK
Tarsney Lake Dam	MO20136	JACKSON CO. PUBLIC WORKS	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Wood Lake Dam	MO20135	CITY OF TARSNEY LAKES	Local Government	Jackson	GRAIN VALLEY	TR SNI-A-BAR CREEK
Pine Lake Dam	MO30447	MO STATE HWY COMMISSION	State	Jefferson	IMPERIAL	TR-ROCK CREEK
E.Br So Fk Blackwater B-19	MO20438	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS	TR-E.BR SO FK.BLACKWATER
E.Br So Fk Blackwater E-24	MO50228	JOHNSON CO SCD	Local Government	Johnson	SWEET SPRINGS, M	TR-E.BR.SO.FK.BLACKWATER
Holden New City Reservoir	MO20532	CITY OF HOLDEN	Local Government	Johnson	KINGSVILLE	TRIB SOUTH FORK BLACKWATER
Holden Reservoir Dam West	MO20194	CITY OF HOLDEN	Local Government	Johnson	HOLDEN	TR-PIN OAK CREEK
Pertle Springs Dam	MO20044	CENTRAL MO STATE COLLEGE	State	Johnson	WARRENSBURG	TR-EAST FORK POST OAK CREEK
Henry Sever Dam	MO10110	MO DEPT OF CONSERVATION	State	Knox	NEWARK	MEYERS BRANCH
Ford Lake Dam	MO11225	LAFAYETTE SOIL & WATER	Local Government	Lafayette	LEXINGTON	TR EAST FORK SNI-A-BAR CREEK
Little Sni-A-Bar #21	MO12103	LITTLE SNI-A-BAR WATERSHED	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #22	MO11970	LITTLE SNI-A-BAR WATERSHED DIS	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Little Sni-A-Bar #23	MO11235	LAF SOIL&WTR CONS DIST	Local Government	Lafayette	LEXINGTON	TR TO LITTLE SNI-A-BAR CREEK
Odessa City Lake Dam	MO20042	CITY OF ODESSA	Local Government	Lafayette	WELLINGTON	TR-EAST FORK SNI-A-BAR CREEK
Wellington Nap C-21	MO10284	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington Nap C-22	MO11228	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR TO MISSOURI RIVER
Wellington Nap C-23	MO10283	LAFAYETTE SOIL & WATER	Local Government	Lafayette	CAMDEN	TR MISSOURI RIVER
Wellington Nap D-21a	MO12000	LAFAYETTE SOIL & WATER	Local Government	Lafayette	WATERLOO	TR-MISSOURI RIVER
Wellington-Nap Wtrshd F-21 Dam	MO10282	WLNGTN-NAP WRSD SUBDISTR	Local Government	Lafayette	NAPOLEON	TR TO HICKLIN BR
Buck-Doe Run Watershed Structure #27a	MO11333	BUCK DOE RUN WSD SUBDST	Local Government	Lewis	CANTON	ARTESIAN BRANCH
City of Lewistown Dam	MO10349	CITY OF LEWISTOWN	Local Government	Lewis	TAYLOR	TR-MIDDLE FABIUS RIVER
Deer Ridge Community Lake Dam	MO10109	MO DEPT OF CONSERVATION	State	Lewis	MONTICELLO	TR-NORTH FABIUS RIVER
La Belle Old City Lake Dam	MO10372	CITY OF LA BELLE	Local Government	Lewis	STEFFENVILLE	TR TROUBLESOME CREEK
Clarence Cannon #15	MO11309	LINCOLN CO SOIL&WATER D	Local Government	Lincoln	ELSBERRY	BRYANTS CREEK
Lake Lincoln Dam	MO10215	MO. DNR PARKS	State	Lincoln	TROY	DRY BRANCH SUGAR CREEK
Lost Cr Pilot Watershed Dam F-4	MO50335	ROBERT PIRTLE	Local Government	Lincoln	ELSBERRY	TR-LOST CREEK
Lost Creek #1	MO10212	LAMMERT FARMS LP	Local Government	Lincoln	ELSBERRY	LOST CREEK
Lost Creek #2	MO10216	LOST CREEK WTRSD SUBDST	Local Government	Lincoln	NEW HOPE	TR-LOST CREEK
Shady Eighty Ranch Lake Dam	MO11306	MO. DNR PARKS	State	Lincoln	MOSCOW MILLS	TR-SUGAR CREEK
White Lake Dam	MO12220	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	MILL CREEK TRIBUTARY
White Memorial Area Sec-16 Lake Dam	MO11286	MO DEPT OF CONSERVATION	State	Lincoln	WHITESIDE	TR-LITTLE SANDY CREEK
Brookfield Reservoir Dam	MO10183	CITY OF BROOKFIELD	Local Government	Linn	BROOKFIELD	WEST YELLOW CREEK-OFFSTREAM
Bucklin City Lake Dam	MO10056	CITY OF BUCKLIN,MO	Local Government	Linn	KEYTESVILLE	TR-VAN DORSEN CREEK
Linneus Lake Dam	MO10437	CITY OF LINNEUS	Local Government	Linn	LINNEUS	TR-LOCUST CREEK
Marceline City Reservoir Dam	MO10119	CITY OF MARCELINE,MO	Local Government	Linn	KEYTESVILLE	CLARKS CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Santa Fe Country Club	MO10765	CITY OF MARCELINE	Local Government	Linn	MARCELINE	TR-EAST YELLOW CREEK
Indian Creek Community Dam	MO12221	MO DEPT OF CONSERVATION	State	Livingston	FARMERSVILLE	INDIAN CREEK (TRIBUTARY)
Macon Lake Dam	MO10153	CITY OF MACON	Local Government	Macon	MACON	DUCK CREEK
New Cambria Lake Dam	MO10387	CITY OF NEW CAMBRIA	Local Government	Macon	NEW CAMBRIA	TR CHARITON RIVER
Southwest City Rc&D Structure E-1	MO20510	MCDON CSW CONS DIST SWC	Local Government	McDonald	SOUTHWEST CITY	TR-HONEY CREEK
Lake Paho Dam	MO10108	MO DEPT OF CONSERVATION	State	Mercer	SPIKARD	WEST MUDDY CREEK
Manito Dam	MO31853	MO DEPT OF CONSERVATION	State	Moniteau	FORTUNA	LITTLE RICHLAND CREEK
Lake Tom Sawyer Dam	MO10058	MARK TWAIN STATE PARK	State	Monroe	FLORIDA	TR-SALT RIVER
Monroe City South Lake Dam	MO10538	CITY OF MONROE	Local Government	Monroe	STOUTSVILLE	TR.TO LITTLE INDIAN CREEK
Wellsville Lake Dam	MO10947	MO DEPT OF CONSERVATION	State	Montgomery	MINEOLA	TR-LITTLE LOUTRE CREEK
Hickory Creek Watershed Structure H- 1a	MO51152	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 2a	MO51159	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY CREEK
Hickory Creek Watershed Structure H- 9a	MO51148	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 10d	MO51150	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Hickory Creek Watershed Structure H- 11	MO51149	CITY OF NEOSHO	Local Government	Newton	NEOSHO	TR-HICKORY
Lost Creek B-2	MO20730	LOST CREEK WATERSHED S.D	Local Government	Newton	RACINE	LOST CREEK
Lost Creek D-1	MO20731	NEWTON CO.SOIL CON. DIST	Local Government	Newton	SENECA	MCDOUGLE CREEK
Lost Creek E-1	MO20511	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek F-3	MO20514	LOST CK WATERSHED SUBDIS	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-1	MO20512	LOST CREEK WRSD SUBDIST	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Dam F-2	MO20513	LOST CR WRSD SUBDISTR	Local Government	Newton	SENECA	TR-LOST CREEK
Lost Creek Watershed Site A-1	MO20781	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
Lost Creek Watershed Site C-2	MO20782	LOST CREEK WATERSHED SBD	Local Government	Newton	SENECA	TRIBUTARY, LITTLE LOST CREEK
102 Riv Trib Wtrshd Strctr Lt-36	MO11258	102 RIV TRIB WRSD SUBDST	Local Government	Nodaway	ARKOE	TR-102 RIVER
102 River Tributaries Dam C-5	MO10996	102 RIV TRIB WRSD SUBDIS	Local Government	Nodaway	MARYVILLE	CANAL BRANCH 102 RIVER
Mozingo Creek Dam	MO12277	CITY OF MARYVILLE	Local Government	Nodaway	MARYVILLE	MOZINGO CREEK
Nodaway Lake Dam	MO10178	MO DEPT OF CONSERVATION	State	Nodaway	MARYVILLE	TR-CANAL BRANCH
Ben Branch Dam	MO31844	MO DEPT OF CONSERVATION	State	Osage	LUYSTOWN	BEN BRANCH
Perry County Comm. Lake Dam	MO30813	MO DEPT OF CONSERVATION	State	Perry	SAINT MARYS	TR-SOUTH FORK SALINE CR
Port Perry Dam	MO30030		State	Perry	SILVER LAKE	TR NATIONS CREEK
Spring Fork Lake Dam	MO30152	CITY OF SEDALIA WATER DP	Local Government	Pettis	SEDALIA	CHEESE CK
Windsor Farrington Park Lake Dam	MO20034	CITY OF WINDSOR	Local Government	Pettis	WINDSOR	TR-ELM BRANCH
William E. Towell Dam	MO30090	MO DEPT OF CONSERVATION	State	Phelps	DILLON	TRIBUTARY OF BOUBEUSE RIVER
Bowling Green Dam #1	MO10262		Local Government	Pike	BOWLING GREEN	TRIBUTARY TO NOIX CREEK
Bowling Green Dam #2	MO12195	CITY OF BOWLING GREEN	Local Government	Pike	BOWLING GREEN	TR BUCKNER HOLLOW
Old Bowling Green Reservoir Dam	MO10263	CITY OF BOWLING GREEN	Local Government	Pike	LOUISIANA	TR-BUCKNER HOLLOW-NOIX CREEK
International Airport Dam	MO10661	CITY OF KANSAS CITY MO	Local Government	Platte	PLATTE CITY	TR TODD CREEK
Unionville Old City Lake Dam	MO10152	UNIONVILLE,MO	Local Government	Putnam	UNIONVILLE	TR-BLACKBIRD CREEK
Bear Creek Dam	MO10977	CITY OF HANNIBAL	Local Government	Ralls	HANNIBAL	BEAR CREEK
Perry City Dam - Lower	MO10675	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH LICK CREEK

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
Perry City Dam No. 2	MO10980	CITY OF PERRY	Local Government	Ralls	PERRY	MACE BRANCH
Higbee Lake Dam	MO10222	MARSHALL BAKER	Local Government	Randolph	BURTON	SALT FK BONNE FEMME CREEK
Rothwell Lake Dam	MO10004	MOBERLY PARKS & RECREATN	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Thomas Hill Reservoir Dam	MO10134	ASSOCIATED ELECTRIC CORP	Public Utility	Randolph	THOMAS HILL	MIDDLE FORK CHARITON RIVER
Water Works Lake Dam	MO10006	MOBERLY-PARKS&RECREATION	Local Government	Randolph	MOBERLY	TRIBUTARY TO SWEET SPRING CRK
Lawson City Lake Dam	MO10147	CITY OF LAWSON	Local Government	Ray	ELMIRA	BRUSHY CREEK
Ray County Lake Dam	MO10098	RAY COUNTY COURT	Local Government	Ray	HODGE	TR-WEST FORK CROOKED RIVER
Richmond Schools Dam	MO10588	RICHMOND SCHOOL DIST R16	Local Government	Ray	HENRIETTA	LICK CREEK
Willow Creek Wtrshd Site A-1	MO11084	WILLOW CREEK WTRSD SUBDS	Local Government	Ray	HENRIETTA	WILLOW CREEK
Taum Sauk Ps Lower	MO30041	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Taum Sauk Ps Upper	MO30040	Union Electric Company	Public Utility	Reynolds	Lesterville	East Fork Black River
Fourche Creek Wtrshd No. 7	MO31408	RIPLEY SOIL/WATER CONSER	Local Government	Ripley	POCAHONTAS ARK	EAST FORK FOURCHE CREEK
Upper Little Black A-2	MO31938	UPPER LITTLE BLACK WATERSHED SUBDISTRICT	Local Government	Ripley	GRANDIN	BEAVER DAM CREEK
Upper Little Black A-7 Dam	MO31829	UPPER LITTLE BLACK SUBD	Local Government	Ripley	GRANDIN	LITTLE BLACK
Upper Little Black D-2	MO31899	UPPER L.BLACK SUBDIST.	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Upper Little Black D-8 Dam	MO31861	DR. MICHAEL SPEZIA	Local Government	Ripley	FAIRDEALING	TR LITTLE BLACK RIVER
Van Meter Dam	MO10658	MO. DNR PARKS	State	Saline	MIAMI	TR MISSOURI RIVER
Lancaster City Dam	MO10851	CITY OF LANCASTER	Local Government	Schuyler	LANCASTER	NO.FORK/MIDDLE FAUBIUS RIVER
Queen City Reservoir Dam	MO10186	QUEEN CITY,MO	Local Government	Schuyler	GREENTOP	#NAME?
Memphis Lake Dam	MO10217		Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Memphis Reservoir Dam	MO10163	CITY OF MEMPHIS	Local Government	Scotland	MEMPHIS	TR-NORTH FABIUS RIVER
Caney Basin Dam	MO40070	LITTLE RVR DRAINAGE DIST	Local Government	Scott	ORAN	CANEY CREEK
Tywappity Community Lake Dam	MO40006	MO DEPT OF CONSERVATION	State	Scott	KELSO	HINDMAN CREEK
Clarence City New Lake Dam	MO10608	CITY OF CLARENCE	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Clarence City Old Lake	MO10609	CITY OF CLARENCE,MO	Local Government	Shelby	CLARENCE	TR TO BATTON BRANCH
Shelbina Lake Dam	MO10057	CITY OF SHELBINA	Local Government	Shelby	FLORIDA	TR TO SALT RIVER
Shelbyville Lake Dam	MO10028	CITY OF SHELBYVILLE	Local Government	Shelby	SHELBYVILLE	TR-BLACK CREEK
August A Busch Lake #16 Dam	MO10089	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CR
August A Busch Lake #51 Dam	MO10093	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR SCHOTE CREEK
August A Busch Lake #570 Dam	MO10095	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-DARDENNE CR
Busch Wildlife #35	MO10092	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	SCHOTE CREEK
Busch Wildlife #37 Dam	MO10088	MO DEPT OF CONSERVATION	State	St. Charles	ST PETERS	TR-KRAUT RUN
Sioux Power Plant Dam	MO40160		Public Utility	St. Charles	PORTAGE DES SIOUX	T MISSISSIPPI
Stergen Lake Dam	MO30606	DESPENA STERGEN	State	St. Charles	FEMME OSAGE	TR-FEMME OSAGE CREEK
Univ Mo Exp Farm Dam- Mononame 207	MO10643	MO DEPT OF CONSERVATION	State	St. Charles	WELDON SPRING	EAST BRANCH OF CROOKED CREEK
H&S Hill Top Lake Dam	MO31189		State	St. Francois	BELLEFONTAME	TR-BIG RIVER
Lakeview Park Dam	MO30288	CITY OF BONNE TERRE	Local Government	St. Francois	BONNE TERRE	TURKEY CREEK
St. Joe State Park Dam	MO30277	MO. DNR PARKS	State	St. Francois	FLAT RIVER	SHAW BRANCH-FLAT RIVER
Bee Tree Lake Dam	MO31378	ST. LOUIS COUNTY	Local Government	St. Louis	HERCULANEUM	TR TO MERAMEC RIVER
City of Fenton Dam #1	MO40138		Local Government	St. Louis	FENTON	

Dam Name	NID ID	Owner Names	Owner Types	County	City	River or Stream Name
City Place Dam	MO31914	CITY OF CREVE COEUR	Local Government	St. Louis	CREVE COEUR	TR CREVE COEUR CREEK
Stacy Park Resevoir Dam	MO31658	CITY OF ST. LOUIS	Local Government	St. Louis	OLIVETTE	RIVER DES PERES
Duck Creek State Wildlife Refuge No 2	MO40093	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek State Wildlife Refuge No 3	MO40094	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	TR-DUCK CREEK
Duck Creek-State Wildlife Refuge-# 1	MO40063	MO DEPT OF CONSERVATION	State	Stoddard	KINDER	CASTOR RIVER
Southwest Rc & D # 1 Dam	MO20509	CITY OF CRANE	Local Government	Stone	CRANE	TR-CRANE CREEK
Elmwood City Lake Dam	MO10240	CITY OF MILAN	Local Government	Sullivan	MILAN	ELMWOOD BRANCH
Sears Community Lake Dam	MO10503	MO DEPT OF CONSERVATION	State	Sullivan	MILAN	TR-EAST LOCUST CREEK
Ozark Beach	MO30088	Empire District Electric Company	Public Utility	Taney	Forsyth	White River
Austin Community Lake Dam	MO30074	MO DEPT OF CONSERVATION	State	Texas	MANES	TR-BEAVER CREEK
Izaak Walton Lake Dam	MO20048	CITY OF NEVADA	Local Government	Vernon	NEVADA	TR TO WHITE BRANCH
Marthasville Mv-5 Dam	MO40111	CITY OF MARTHASVILLE	Local Government	Warren	MARTHASVILLE	TRIB TO TUQUE CREEK
Casey Lake Dam	MO30695	CASEY WOJCIECHOWSKI	State	Washington	LEADWOOD	TR-CLEAR CREEK
Lac Shayne Dam	MO31835	TERRE DU LAC POA	Local Government	Washington	TERRE DU LAC	POND CREEK
Lake Apache Dam	MO30703	CITY OF IRONDALE	Local Government	Washington	IRONDALE	TR DRY CREEK
Eagle Sky Lake Dam	MO30007	CLAUDE KENNEDY	State	Wayne	PATTERSON	CAMP CREEK
Platte River Trib Watershed Dam 3-B	MO11054	PLATTE RVR TR WTSH DIST.	Local Government	Worth	SHERIDAN	TR-PLATTE RIVER

Table A.8 provides the results of the inundation area analysis with the numbers and values of various types of structures, and population within the mapped inundation areas for State-Regulated Dams. The table that follows provides the same analysis results of the inundation area analysis of available USACE dams. Counties not included in table did not have structures in available dam inundation areas.

Table A.8. Estimated Numbers and Values of Structures and Population Vulnerable to Failure of State-Regulated Dams with Available Inundation Areas

County	Number of Structures	Value of Structures	Population
Adair	**6**	**$2,627,804**	5
Agriculture	4	$2,110,300	0
Residential	2	$517,504	5
Andrew	**109**	**$31,156,062**	195
Agriculture	26	$6,854,776	0
Commercial	4	$2,749,242	0
Government	1	$888,127	0
Industrial	2	$758,519	0
Residential	76	$19,905,398	195
Atchison	**2**	**$1,188,875**	0
Agriculture	2	$1,188,875	0
Bollinger	**8**	**$6,506,107**	0
Agriculture	8	$6,506,107	0
Boone	**61**	**$22,502,780**	103
Agriculture	13	$4,735,694	0
Commercial	2	$2,168,575	0
Industrial	3	$1,952,779	0
Residential	43	$13,645,732	103
Buchanan	**3**	**$817,661**	8
Residential	3	$817,661	8
Butler	**18**	**$6,054,075**	20
Agriculture	10	$4,268,436	0
Residential	8	$1,785,639	20
Caldwell	**1**	**$224,916**	2
Residential	1	$224,916	2
Callaway	**19**	**$7,760,768**	15
Agriculture	7	$1,648,083	0
Commercial	5	$3,815,470	0
Industrial	1	$759,213	0
Residential	6	$1,538,001	15
Camden	**16**	**$7,255,968**	25
Agriculture	3	$873,493	0
Commercial	4	$3,923,317	0
Residential	9	$2,459,158	25
Cass	**150**	**$59,444,884**	150
Agriculture	59	$19,408,826	0
Commercial	33	$21,877,498	0
Residential	58	$18,158,559	150

County	Number of Structures	Value of Structures	Population
Chariton	**28**	**$31,862,629**	8
Agriculture	25	$31,196,014	0
Residential	3	$666,615	8
Christian	**49**	**$23,227,907**	32
Agriculture	19	$4,731,559	0
Commercial	11	$6,719,947	0
Industrial	7	$8,395,314	0
Residential	12	$3,381,088	32
Clark	**2**	**$1,526,243**	0
Agriculture	1	$878,536	0
Commercial	1	$647,707	0
Clay	**133**	**$92,580,180**	197
Agriculture	7	$2,001,237	0
Commercial	50	$64,219,612	0
Government	1	$1,363,241	0
Residential	75	$24,996,090	197
Clinton	**33**	**$13,556,668**	39
Agriculture	3	$647,775	0
Commercial	13	$7,622,893	0
Government	1	$702,478	0
Residential	16	$4,583,522	39
Cole	**23**	**$7,236,513**	50
Agriculture	2	$552,270	0
Residential	21	$6,684,243	50
Crawford	**30**	**$7,065,806**	47
Agriculture	10	$2,513,017	0
Commercial	1	$674,635	0
Residential	19	$3,878,153	47
Daviess	**13**	**$5,683,705**	5
Agriculture	8	$1,957,905	0
Industrial	3	$3,276,610	0
Residential	2	$449,189	5
Dekalb	**38**	**$19,771,340**	7
Agriculture	11	$2,747,055	0
Commercial	24	$16,164,741	0
Residential	3	$859,544	7
Dent	**12**	**$6,773,658**	2
Agriculture	10	$5,637,644	0
Commercial	1	$935,585	0
Residential	1	$200,429	2
Franklin	**147**	**$40,219,069**	290
Agriculture	14	$54,251	0
Commercial	17	$9,515,629	0
Residential	116	$30,649,189	290
Gasconade	**38**	**$13,011,079**	7

County	Number of Structures	Value of Structures	Population
Agriculture	29	$8,003,480	0
Commercial	5	$3,351,371	0
Government	1	$972,112	0
Residential	3	$684,117	7
Greene	**144**	**$61,089,843**	144
Agriculture	57	$17,595,114	0
Commercial	8	$8,346,771	0
Government	14	$15,954,276	0
Residential	65	$19,193,682	144
Grundy	**21**	**$5,400,610**	2
Agriculture	20	$5,166,272	0
Residential	1	$234,338	2
Harrison	**10**	**$2,373,671**	0
Agriculture	10	$2,373,671	0
Howard	**14**	**$5,257,068**	19
Commercial	7	$3,595,701	0
Residential	7	$1,661,367	19
Iron	**74**	**$21,273,965**	130
Agriculture	13	$4,402,861	0
Commercial	2	$1,214,077	0
Government	2	$1,316,447	0
Industrial	3	$4,039,390	0
Residential	54	$10,301,191	130
Jackson	**1,813**	**$1,481,130,454**	2184
Agriculture	33	$11,653,441	0
Commercial	862	$1,164,527,949	0
Education	4	$10,806,427	0
Residential	914	$294,142,638	2184
Jefferson	**9**	**$2,554,496**	3
Agriculture	8	$2,347,252	0
Residential	1	$207,244	3
Johnson	**16**	**$4,972,799**	32
Agriculture	2	$491,535	0
Commercial	1	$770,662	0
Residential	13	$3,710,602	32
Knox	**1**	**$1,533,567**	0
Agriculture	1	$1,533,567	0
Lafayette	**27**	**$8,696,070**	20
Agriculture	19	$6,533,151	0
Residential	8	$2,162,919	20
Lewis	**44**	**$35,626,664**	10
Agriculture	40	$34,731,361	0
Residential	4	$895,303	10
Lincoln	**49**	**$2,213,025**	90
Agriculture	13	$3,275	0

County	Number of Structures	Value of Structures	Population
Commercial	5	$1,932,636	0
Residential	31	$277,114	90
Linn	**25**	**$11,247,165**	30
Agriculture	1	$272,698	0
Commercial	11	$7,996,679	0
Residential	13	$2,977,788	30
Livingston	**23**	**$7,106,615**	5
Agriculture	21	$6,633,393	0
Residential	2	$473,222	5
Macon	**10**	**$2,653,678**	20
Agriculture	1	$250,914	0
Commercial	1	$718,869	0
Residential	8	$1,683,895	20
Madison	**23**	**$6,847,617**	40
Agriculture	2	$583,866	0
Commercial	3	$2,157,718	0
Industrial	1	$943,109	0
Residential	17	$3,162,925	40
Maries	**18**	**$5,443,719**	32
Agriculture	1	$250,914	0
Commercial	3	$2,156,605	0
Residential	14	$3,036,200	32
Marion	**708**	**$329,079,785**	997
Commercial	264	$198,416,673	0
Government	9	$7,843,663	0
Industrial	9	$8,837,708	0
Residential	426	$113,981,741	997
Mercer	**2**	**$1,206,027**	3
Agriculture	1	$911,683	0
Residential	1	$294,344	3
Moniteau	**1**	**$247,313**	3
Residential	1	$247,313	3
Montgomery	**39**	**$10,388,305**	11
Agriculture	34	$9,330,143	0
Residential	5	$1,058,163	11
Morgan	**2**	**$464,563**	3
Agriculture	1	$271,076	0
Residential	1	$193,487	3
Newton	**466**	**$164,575,218**	830
Agriculture	59	$13,400,968	0
Commercial	79	$61,022,139	0
Education	5	$19,411,048	0
Residential	323	$70,741,063	830
Nodaway	**39**	**$13,799,447**	21
Agriculture	30	$11,150,351	0

County	Number of Structures	Value of Structures	Population
Residential	9	$2,649,096	21
Osage	**36**	**$27,181,378**	3
Agriculture	35	$26,934,139	0
Residential	1	$247,240	3
Perry	**62**	**$280,377**	57
Agriculture	39	$6,346	0
Residential	23	$274,031	57
Pettis	**5**	**$1,686,051**	0
Agriculture	5	$1,686,051	0
Phelps	**52**	**$13,012,251**	88
Agriculture	14	$3,222,564	0
Residential	38	$9,789,688	88
Pike	**27**	**$2,023,541**	27
Agriculture	4	$5,670	0
Commercial	5	$430,132	0
Industrial	7	$317,248	0
Residential	11	$1,270,490	27
Platte	**175**	**$108,478,795**	**269**
Agriculture	8	$2,425,473	0
Commercial	56	$59,248,958	0
Education	1	$2,061,764	0
Government	2	$2,885,677	0
Industrial	2	$2,192,478	0
Residential	106	$39,664,446	269
Polk	**10**	**$2,569,180**	8
Agriculture	7	$1,940,385	0
Residential	3	$628,795	8
Putnam	**16**	**$14,101,328**	3
Agriculture	15	$13,919,668	0
Residential	1	$181,659	3
Ralls	**185**	**$105,080,238**	269
Agriculture	5	$1,301,181	0
Commercial	33	$16,600,643	0
Industrial	40	$63,071,935	0
Residential	107	$24,106,479	269
Randolph	**4**	**$2,310,866**	0
Agriculture	4	$2,310,866	0
Ray	**12**	**$6,611,092**	5
Agriculture	3	$1,328,579	0
Commercial	7	$4,730,945	0
Residential	2	$551,568	5
Ripley	**23**	**$1,371,752**	21
Agriculture	15	$25,033	0
Residential	8	$1,346,720	21
Saline	**6**	**$3,096,485**	0

County	Number of Structures	Value of Structures	Population
Agriculture	6	$3,096,485	0
Scotland	**27**	**$23,215,300**	0
Agriculture	4	$4,781,420	0
Commercial	20	$16,678,387	0
Government	3	$1,755,493	0
Scott	**41**	**$10,804,078**	65
Agriculture	15	$4,986,023	0
Residential	26	$5,818,054	65
Shelby	**1**	**$297,790**	0
Agriculture	1	$297,790	0
Ste Genevieve	**17**	**$1,123,121**	15
Agriculture	11	$167,517	0
Residential	6	$955,603	15
St Louis	**6**	**$1,251,517**	0
Agriculture	6	$1,251,517	0
Stone	**205**	**$85,568,808**	242
Agriculture	11	$3,524,110	0
Commercial	83	$53,649,014	0
Government	4	$2,499,644	0
Industrial	8	$3,668,164	0
Residential	99	$22,227,877	242
Taney	**3**	**$1,962,194**	0
Agriculture	1	$255,553	0
Commercial	2	$1,706,640	0
Warren	**215**	**$13,460,922**	138
Agriculture	162	$3,263,370	0
Commercial	2	$723,221	0
Residential	51	$9,474,330	138
Washington	**48**	**$1,597,965**	15
Agriculture	37	$153,035	0
Commercial	5	$863,544	0
Residential	6	$581,386	15
Wayne	**40**	**$9,210,662**	41
Agriculture	23	$6,429,922	0
Residential	17	$2,780,739	41
Webster	**2**	**$496,476**	3
Agriculture	1	$292,122	0
Residential	1	$204,354	3
Grand Total	**5,735**	**$3,030,028,544**	**7,105**

Source: Missouri Department of Natural Resources, MSDIS Structure Inventory, HAZUS Building Exposure

Table A.9. Estimated Numbers and Values of Structures and Population Vulnerable to Failure of USACE Dams with Available Inundation Areas

County	Number of Structures	Value of Structures	Population
Adair	**255**	**$108,530,816**	**250**
Agriculture	136	$71,750,179	0
Commercial	12	$8,629,878	0
Government	1	$723,049	0
Residential	106	$27,427,711	250
Andrew	**494**	**$143,341,496**	**638**
Agriculture	213	$56,156,426	0
Commercial	14	$9,622,347	0
Government	12	$10,657,528	0
Industrial	1	$379,259	0
Residential	254	$66,525,937	638
Atchison	**2,595**	**$1,453,593,301**	**731**
Agriculture	2,058	$1,223,351,619	0
Commercial	106	$81,205,390	0
Government	8	$4,601,395	0
Industrial	80	$52,093,742	0
Residential	343	$92,341,155	731
Bates	**64**	**$48,633,792**	**32**
Agriculture	43	$40,497,501	0
Commercial	5	$3,618,723	0
Education	3	$1,722,568	0
Residential	13	$2,795,000	32
Benton	**3,505**	**$1,567,438,688**	**4,640**
Agriculture	4	$4,492,829	0
Commercial	1,454	$1,161,186,029	0
Government	11	$9,698,992	0
Industrial	1	$1,152,878	0
Residential	2,035	$390,907,960	4,640
Bollinger	**8**	**$6,506,107**	**0**
Agriculture	8	$6,506,107	0
Boone	**2,189**	**$772,473,140**	**4,422**
Agriculture	304	$110,742,399	0
Commercial	19	$20,601,455	0
Education	8	$31,359,354	0
Government	20	$25,493,440	0
Industrial	3	$1,952,779	0
Residential	1,835	$582,323,712	4,422
Buchanan	**6,038**	**$3,371,471,352**	**9,079**
Agriculture	1,019	$300,679,083	0
Commercial	475	$552,108,073	0
Education	13	$18,287,041	0
Government	117	$125,819,740	0

County	Number of Structures	Value of Structures	Population
Industrial	895	$1,415,460,841	0
Residential	3,519	$959,116,574	9,079
Butler	**18**	**$6,054,075**	**20**
Agriculture	10	$4,268,436	0
Residential	8	$1,785,639	20
Callaway	**1,001**	**$292,290,251**	**887**
Agriculture	556	$130,904,904	0
Commercial	38	$28,997,576	0
Government	16	$12,549,094	0
Industrial	39	$29,609,335	0
Residential	352	$90,229,342	887
Camden	**25,253**	**$17,570,378,473**	**26,341**
Agriculture	43	$12,520,073	0
Commercial	15,073	$14,784,037,960	0
Government	6	$5,628,074	0
Residential	10,131	$2,768,192,365	26,341
Carroll	**3,514**	**$2,180,881,641**	**2,812**
Agriculture	2,194	$1,723,806,216	0
Commercial	113	$90,475,267	0
Education	4	$5,321,334	0
Government	26	$24,415,532	0
Industrial	43	$61,444,120	0
Residential	1,134	$275,419,172	2,812
Cedar	**190**	**$66,218,780**	**110**
Agriculture	141	$55,798,831	0
Industrial	2	$2,075,260	0
Residential	47	$8,344,688	110
Chariton	**3,082**	**$2,906,219,378**	**2,145**
Agriculture	2,097	$2,616,721,683	0
Commercial	117	$87,911,459	0
Education	1	$2,820,942	0
Government	7	$2,922,735	0
Industrial	9	$6,746,253	0
Residential	851	$189,096,307	2,145
Clark	**488**	**$336,275,996**	**315**
Agriculture	337	$296,066,679	0
Commercial	19	$12,306,429	0
Government	2	$1,037,990	0
Residential	130	$26,864,897	315
Clay	**3,797**	**$2,401,141,476**	**5,975**
Agriculture	335	$95,773,470	0
Commercial	666	$855,405,224	0
Education	9	$21,108,963	0
Government	38	$51,803,156	0
Industrial	451	$611,170,441	0

County	Number of Structures	Value of Structures	Population
Residential	2,298	$765,880,223	5,975
Cole	**2,460**	**$911,222,840**	**4,221**
Agriculture	518	$143,037,980	0
Commercial	98	$95,291,292	0
Education	11	$21,238,324	0
Government	23	$39,317,895	0
Industrial	80	$61,683,014	0
Residential	1,730	$550,654,336	4,221
Cooper	**1,060**	**$315,331,981**	**1,279**
Agriculture	426	$116,195,683	0
Commercial	95	$60,635,537	0
Government	11	$5,625,819	0
Industrial	10	$8,459,287	0
Residential	518	$124,415,655	1,279
Franklin	**2948**	**$926,689,559**	**4,951**
Agriculture	906	$3,510,768	0
Commercial	294	$164,564,407	0
Education	11	$11,504,454	0
Government	5	$2,907,994	0
Industrial	135	$322,247,154	0
Residential	1597	$421,954,782	4,951
Gasconade	**1,493**	**$490,199,637**	**1,535**
Agriculture	611	$168,625,039	0
Commercial	205	$137,406,201	0
Education	11	$22,733,749	0
Government	6	$5,832,673	0
Industrial	7	$6,692,531	0
Residential	653	$148,909,444	1,535
Hickory	**248**	**$74,963,998**	**394**
Agriculture	22	$9,008,930	0
Commercial	40	$29,717,018	0
Education	3	$6,139,932	0
Government	8	$5,809,483	0
Residential	175	$24,288,635	394
Holt	**3,344**	**$1,035,501,866**	**2,222**
Agriculture	2,036	$665,336,590	0
Commercial	146	$80,883,298	0
Education	2	$3,886,714	0
Government	31	$17,223,955	0
Industrial	76	$49,942,995	0
Residential	1,053	$218,228,314	2,222
Howard	**787**	**$229,906,722**	**982**
Agriculture	269	$70,800,012	0
Commercial	102	$52,394,505	0
Industrial	28	$14,624,975	0

County	Number of Structures	Value of Structures	Population
Residential	388	$92,087,230	982
Iron	**74**	**$21,273,965**	**133**
Agriculture	13	$4,402,861	0
Commercial	2	$1,214,077	0
Government	2	$1,316,447	0
Industrial	3	$4,039,390	0
Residential	54	$10,301,191	133
Jackson	**7,312**	**$5,368,656,431**	**9,967**
Agriculture	510	$180,098,625	0
Commercial	807	$1,090,225,121	0
Education	11	$29,717,673	0
Government	24	$41,722,484	0
Industrial	1,875	$2,712,261,594	0
Residential	4,085	$1,314,630,934	9,967
Lafayette	**443**	**$111,139,542**	**315**
Agriculture	279	$47,745,444	0
Commercial	16	$13,144,844	0
Education	1	$2,401,197	0
Government	1	$655,461	0
Industrial	17	$12,315,521	0
Residential	129	$34,877,075	315
Lewis	**1,739**	**$666,962,608**	**2,913**
Agriculture	184	$159,764,261	0
Commercial	275	$157,772,970	0
Education	4	$7,061,790	0
Government	17	$8,386,962	0
Industrial	70	$67,848,006	0
Residential	1,189	$266,128,619	2,913
Lincoln	**460**	**$71,335,343**	**706**
Agriculture	205	$671,340	0
Residential	255	$70,664,003	706
Linn	**41**	**$11,242,151**	**23**
Agriculture	31	$8,453,634	0
Commercial	1	$726,971	0
Residential	9	$2,061,546	23
Livingston	**168**	**$51,271,677**	**74**
Agriculture	136	$42,959,116	0
Commercial	1	$977,631	0
Residential	31	$7,334,931	74
Macon	**239**	**$60,978,667**	**141**
Agriculture	176	$44,160,908	0
Commercial	1	$718,869	0
Government	4	$3,890,648	0
Residential	58	$12,208,242	141
Madison	**23**	**$6,847,617**	**45**

County	Number of Structures	Value of Structures	Population
Agriculture	2	$583,866	0
Commercial	3	$2,157,718	0
Industrial	1	$943,109	0
Residential	17	$3,162,925	45
Marion	**528**	**$213,084,295**	**544**
Agriculture	169	$45,649,591	0
Commercial	104	$78,164,144	0
Government	10	$8,715,182	0
Industrial	21	$20,621,318	0
Residential	224	$59,934,061	544
Miller	**2,434**	**$1,027,183,495**	**2,438**
Agriculture	406	$118,898,272	0
Commercial	1,068	$700,338,572	0
Government	6	$3,793,234	0
Industrial	20	$12,994,088	0
Residential	934	$191,159,330	2,438
Moniteau	**487**	**$127,025,410**	**233**
Agriculture	397	$104,431,539	0
Commercial	1	$582,993	0
Residential	89	$22,010,878	233
Montgomery	**1,166**	**$313,538,473**	**533**
Agriculture	925	$253,834,774	0
Commercial	10	$6,437,288	0
Industrial	6	$5,649,108	0
Residential	225	$47,617,303	533
Morgan	**10,228**	**$4,984,904,235**	**10,904**
Agriculture	87	$23,583,636	0
Commercial	5,861	$4,131,456,621	0
Education	1	$792,486	0
Industrial	3	$1,722,940	0
Residential	4,276	$827,348,552	10,904
Osage	**1,557**	**$1,042,385,620**	**1,195**
Agriculture	983	$756,464,523	0
Commercial	60	$46,549,840	0
Education	9	$36,222,463	0
Government	2	$1,634,152	0
Industrial	47	$88,773,296	0
Residential	456	$112,741,347	1,195
Ozark	**172**	**$126,738,540**	**24**
Agriculture	7	$3,430,931	0
Commercial	154	$107,252,966	0
Residential	11	$1,891,821	24
Pettis	**21**	$7,081,412	**0**
Agriculture	21	$7,081,412	0
Pike	**459**	**$71,365,122**	**658**

County	Number of Structures	Value of Structures	Population
Agriculture	97	$549,986	0
Commercial	83	$35,701,004	0
Government	8	$2,199,886	0
Industrial	8	$2,537,982	0
Residential	263	$30,376,263	658
Platte	**3,285**	**$1,774,326,274**	**4,640**
Agriculture	600	$181,910,427	0
Commercial	434	$459,179,431	0
Education	14	$28,864,695	0
Government	40	$57,713,527	0
Industrial	311	$340,930,409	0
Residential	1,886	$705,727,785	4,640
Putnam	**88**	**$67,604,907**	**40**
Agriculture	68	$63,102,495	0
Commercial	2	$1,232,537	0
Residential	18	$3,269,876	40
Ralls	**464**	**$134,213,260**	**344**
Agriculture	295	$76,769,687	0
Commercial	20	$10,060,995	0
Government	5	$4,128,181	0
Industrial	8	$12,614,387	0
Residential	136	$30,640,010	344
Randolph	**31**	**$15,407,030**	**19**
Agriculture	24	$13,865,198	0
Residential	7	$1,541,833	19
Ray	**2,053**	**$847,213,957**	**2,601**
Agriculture	899	$398,130,741	0
Commercial	92	$62,178,136	0
Education	20	$70,482,819	0
Government	7	$5,912,062	0
Industrial	46	$37,760,036	0
Residential	989	$272,750,163	2,601
Ripley	**23**	**$1,371,752**	**21**
Agriculture	15	$25,033	0
Residential	8	$1,346,720	21
Saline	**796**	**$389,262,723**	**508**
Agriculture	555	$286,424,807	0
Commercial	4	$3,086,315	0
Education	1	$2,047,442	0
Government	1	$655,461	0
Industrial	30	$40,513,024	0
Residential	205	$56,535,675	508
Schuyler	**60**	**$49,561,368**	**10**
Agriculture	56	$48,747,915	0
Residential	4	$813,453	10

County	Number of Structures	Value of Structures	Population
Scott	**41**	**$10,804,078**	**66**
Agriculture	15	$4,986,023	0
Residential	26	$5,818,054	66
St Charles	**8,323**	**$3,472,275,896**	**15,971**
Agriculture	2,194	$39,133,741	0
Commercial	847	$887,136,078	0
Education	6	$18,755,483	0
Government	38	$71,249,708	0
Industrial	247	$645,532,275	0
Residential	4,991	$1,810,468,611	15,971
St Clair	**177**	**$85,983,614**	**106**
Agriculture	118	$66,966,031	0
Commercial	10	$8,521,755	0
Government	3	$2,778,590	0
Residential	46	$7,717,239	106
St Louis	**5,799**	**$3,723,966,073**	**7477**
Agriculture	326	$67,999,040	0
Commercial	2,366	$1,278,097,807	0
Education	33	$63,421,959	0
Government	103	$92,304,103	0
Industrial	559	$1,513,464,857	0
Residential	2,412	$708,678,307	7477
St Louis City	**6**	**$9,648,017**	**3**
Commercial	5	$9,260,307	0
Residential	1	$387,710	3
Taney	**4,065**	**$1,616,373,855**	**7,069**
Agriculture	221	$56,477,273	0
Commercial	863	$736,415,240	0
Government	44	$37,873,979	0
Industrial	28	$12,109,847	0
Residential	2,909	$773,497,516	7,069
Vernon	**2**	**$1,541,845**	**0**
Agriculture	2	$1,541,845	0
Warren	**1,509**	**$153,198,368**	**810**
Agriculture	1,188	$5,297,940	0
Commercial	13	$95,103,604	0
Government	1	$3,939,002	0
Residential	307	$48,857,822	810
Wayne	**40**	**$9,210,662**	**41**
Agriculture	23	$6,429,922	0
Residential	17	$2,780,739	41
Grand Total	**119,144**	**$63,860,243,651**	**144553**

Source: U.S. Army Corps of Engineers, MSDIS Structure Inventory, HAZUS Building Exposure

Earthquake – State Vulnerability Tables

The total annualized expected losses by county (including building and income losses) are presented in **Table A.10,** sorted by greatest annualized loss. Included in the table are the annualized loss ratios. The top 10 counties in terms of the highest annualized loss ratio are highlighted.

Table A.10. Hazus Earthquake Loss Estimation: Annualized Loss Scenario

County	Total Losses (in $ Thousands)	Loss Per Capita (in $ Thousands)	Annualized Loss Ratio (in $ per Million)
St. Louis	$20,877	$0.0209	$150
St. Louis City	$11,025	$0.0345	$235
Cape Girardeau	$5,394	$0.0713	$613
Scott	$5,204	$0.1328	$1,289
St. Charles	$4,846	$0.0134	$116
Dunklin	$3,943	$0.1234	$1,325
New Madrid	$3,571	$0.1884	$2,023
Pemiscot	$3,170	$0.1733	$1,930
Jefferson	$3,128	$0.0143	$141
Stoddard	$2,655	$0.0886	$888
Butler	$2,554	$0.0597	$616
Mississippi	$2,043	$0.1423	$1,833
St. Francois	$1,400	$0.0214	$227
Greene	$1,337	$0.0049	$42
Franklin	$947	$0.0093	$83
Perry	$941	$0.0496	$421
Howell	$678	$0.0168	$191
Boone	$552	$0.0034	$30
Ste. Genevieve	$484	$0.0267	$224
Jackson	$478	$0.0007	$5
Ripley	$430	$0.0305	$380
Cole	$372	$0.0049	$35
Wayne	$361	$0.0267	$288
Pulaski	$342	$0.0065	$64
Phelps	$334	$0.0074	$70
Bollinger	$319	$0.0258	$308
Madison	$297	$0.0243	$262
Washington	$265	$0.0105	$153
Crawford	$260	$0.0105	$109
Christian	$248	$0.0032	$32
Lincoln	$240	$0.0046	$51
Iron	$222	$0.0208	$226
Camden	$217	$0.0049	$26
Warren	$210	$0.0065	$60
Jasper	$191	$0.0016	$16
Taney	$189	$0.0037	$31
Laclede	$182	$0.0051	$57
Oregon	$178	$0.0164	$200
Dent	$177	$0.0113	$122
Texas	$172	$0.0066	$75
Reynolds	$167	$0.0249	$249
Callaway	$158	$0.0036	$36
Carter	$157	$0.0251	$302
Shannon	$154	$0.0182	$226
Clay	$149	$0.0007	$5
Webster	$124	$0.0034	$45
Wright	$118	$0.0063	$74

County	Total Losses (in $ Thousands)	Loss Per Capita (in $ Thousands)	Annualized Loss Ratio (in $ per Million)
Audrain	$118	$0.0046	$44
Gasconade	$114	$0.0075	$60
Barry	$107	$0.0030	$29
Lawrence	$92	$0.0024	$26
Newton	$92	$0.0016	$17
Stone	$83	$0.0026	$21
Pettis	$81	$0.0019	$18
Polk	$78	$0.0025	$29
Miller	$72	$0.0029	$30
Montgomery	$70	$0.0057	$50
Ozark	$67	$0.0069	$73
Pike	$67	$0.0036	$36
Johnson	$66	$0.0013	$11
Morgan	$63	$0.0031	$22
Cass	$62	$0.0006	$6
Douglas	$61	$0.0045	$59
Osage	$58	$0.0042	$36
Platte	$52	$0.0006	$5
Cooper	$50	$0.0028	$28
Maries	$48	$0.0053	$51
Dallas	$48	$0.0029	$35
Buchanan	$48	$0.0005	$5
Randolph	$47	$0.0019	$20
Benton	$46	$0.0024	$19
Henry	$44	$0.0020	$17
Marion	$37	$0.0013	$12
Saline	$36	$0.0015	$15
Vernon	$33	$0.0016	$15
Moniteau	$32	$0.0020	$21
Lafayette	$32	$0.0009	$8
Barton	$26	$0.0021	$18
Ralls	$25	$0.0024	$21
Macon	$20	$0.0013	$12
Cedar	$20	$0.0014	$15
Ray	$20	$0.0008	$8
Adair	$19	$0.0008	$7
Monroe	$19	$0.0022	$20
Howard	$19	$0.0018	$17
Dade	$19	$0.0024	$25
Bates	$16	$0.0009	$9
Lewis	$15	$0.0015	$15
Shelby	$14	$0.0022	$18
Livingston	$14	$0.0009	$8
McDonald	$14	$0.0006	$8
St. Clair	$13	$0.0013	$14
Hickory	$12	$0.0012	$14
Clinton	$12	$0.0006	$5
Linn	$11	$0.0009	$7
Carroll	$11	$0.0012	$9
Clark	$8	$0.0012	$12
Nodaway	$8	$0.0004	$3
Chariton	$7	$0.0009	$8
Andrew	$6	$0.0003	$3
Grundy	$6	$0.0005	$5

County	Total Losses (in $ Thousands)	Loss Per Capita (in $ Thousands)	Annualized Loss Ratio (in $ per Million)
Scotland	$5	$0.0011	$10
Caldwell	$5	$0.0005	$5
Knox	$4	$0.0010	$9
Daviess	$4	$0.0005	$4
DeKalb	$4	$0.0003	$4
Harrison	$4	$0.0004	$4
Sullivan	$3	$0.0005	$5
Gentry	$3	$0.0004	$4
Putnam	$3	$0.0005	$5
Holt	$3	$0.0005	$4
Schuyler	$2	$0.0005	$5
Atchison	$2	$0.0003	$2
Mercer	$1	$0.0004	$4
Worth	$0	$0.0002	$2
Total	**$83,762**		

Table A.11. FEMA National Risk Index Loss Estimation: Annualized Loss Scenario

County	Annualized Frequency	Expected Annual Loss Buildings (in $ Thousands)	Expected Annual Loss - Fatalities	Expected Annual Loss - Population Equivalence	Expected Annual Loss - Total	Expected Annual Loss Rating
Adair	0.00032	$19	0.00019	$1,410	$20,868	Very Low
Andrew	0.00019	$6	0.00005	$370	$6,107	Very Low
Atchison	0.00018	$2	0.00001	$79	$2,038	Very Low
Audrain	0.00090	$118	0.00181	$13,770	$131,335	Relatively Low
Barry	0.00052	$107	0.00105	$8,004	$114,531	Very Low
Barton	0.00061	$26	0.00027	$2,064	$27,969	Very Low
Bates	0.00043	$16	0.00013	$974	$16,520	Very Low
Benton	0.00047	$46	0.00035	$2,693	$48,992	Very Low
Bollinger	0.00300	$319	0.01369	$104,070	$422,805	Relatively Low
Boone	0.00059	$552	0.00767	$58,303	$610,301	Relatively Low
Buchanan	0.00020	$48	0.00031	$2,362	$50,220	Very Low
Butler	0.00375	$2,554	0.09899	$752,297	$3,306,296	Relatively Moderate
Caldwell	0.00027	$5	0.00004	$305	$5,060	Very Low
Callaway	0.00079	$158	0.00240	$18,275	$176,345	Relatively Low
Camden	0.00057	$217	0.00137	$10,439	$227,486	Relatively Low
Cape Girardeau	0.00320	$5,394	0.19573	$1,487,566	$6,881,496	Relatively Moderate
Carroll	0.00040	$11	0.00007	$563	$11,376	Very Low
Carter	0.00250	$157	0.00830	$63,089	$220,032	Relatively Low
Cass	0.00037	$62	0.00057	$4,324	$66,744	Very Low
Cedar	0.00041	$20	0.00020	$1,511	$21,497	Very Low
Chariton	0.00047	$7	0.00005	$392	$7,474	Very Low

County	Annualized Frequency	Expected Annual Loss Buildings (in $ Thousands)	Expected Annual Loss - Fatalities	Expected Annual Loss - Population Equivalence	Expected Annual Loss - Total	Expected Annual Loss Rating
Christian	0.00072	$248	0.00438	$33,299	$280,940	Relatively Low
Clark	0.00035	$8	0.00007	$520	$8,862	Very Low
Clay	0.00025	$149	0.00100	$7,620	$156,495	Relatively Low
Clinton	0.00031	$12	0.00010	$746	$12,389	Very Low
Cole	0.00060	$372	0.00367	$27,897	$399,585	Relatively Low
Cooper	0.00049	$50	0.00061	$4,610	$54,740	Very Low
Crawford	0.00139	$260	0.00580	$44,052	$303,564	Relatively Low
Dade	0.00051	$19	0.00027	$2,029	$20,558	Very Low
Dallas	0.00063	$48	0.00098	$7,421	$55,484	Very Low
Daviess	0.00025	$4	0.00003	$205	$4,217	Very Low
DeKalb	0.00028	$4	0.00004	$282	$4,173	Very Low
Dent	0.00153	$177	0.00444	$33,732	$210,922	Relatively Low
Douglas	0.00104	$61	0.00137	$10,394	$71,892	Very Low
Dunklin	0.00459	$3,943	0.19882	$1,511,028	$5,454,319	Relatively Moderate
Franklin	0.00129	$947	0.01661	$126,248	$1,072,941	Relatively Low
Gasconade	0.00094	$114	0.00168	$12,758	$126,882	Relatively Low
Gentry	0.00022	$3	0.00002	$157	$3,109	Very Low
Greene	0.00065	$1,337	0.01993	$151,496	$1,488,379	Relatively Low
Grundy	0.00022	$6	0.00004	$288	$5,907	Very Low
Harrison	0.00022	$4	0.00002	$187	$3,829	Very Low
Henry	0.00051	$44	0.00038	$2,852	$47,034	Very Low
Hickory	0.00051	$12	0.00010	$730	$12,616	Very Low
Holt	0.00023	$3	0.00001	$99	$2,600	Very Low
Howard	0.00042	$19	0.00018	$1,351	$20,003	Very Low
Howell	0.00172	$678	0.02373	$180,376	$858,449	Relatively Low
Iron	0.00216	$222	0.00625	$47,481	$269,071	Relatively Low
Jackson	0.00024	$478	0.00321	$24,418	$502,772	Relatively Low
Jasper	0.00057	$191	0.00186	$14,165	$205,488	Relatively Low
Jefferson	0.00189	$3,128	0.08297	$630,607	$3,758,805	Relatively Moderate
Johnson	0.00041	$66	0.00051	$3,842	$69,946	Very Low
Knox	0.00043	$4	0.00003	$216	$4,230	Very Low
Laclede	0.00081	$182	0.00259	$19,700	$201,558	Relatively Low
Lafayette	0.00034	$32	0.00025	$1,869	$33,559	Very Low
Lawrence	0.00051	$92	0.00127	$9,655	$102,019	Very Low
Lewis	0.00044	$15	0.00017	$1,288	$16,515	Very Low
Lincoln	0.00099	$240	0.00512	$38,927	$278,784	Relatively Low
Linn	0.00033	$11	0.00008	$590	$12,089	Very Low

County	Annualized Frequency	Expected Annual Loss Buildings (in $ Thousands)	Expected Annual Loss - Fatalities	Expected Annual Loss - Population Equivalence	Expected Annual Loss - Total	Expected Annual Loss Rating
Livingston	0.00031	$14	0.00010	$733	$14,749	Very Low
McDonald	0.00037	$14	0.00016	$1,183	$15,054	Very Low
Macon	0.00041	$20	0.00016	$1,191	$21,435	Very Low
Madison	0.00255	$297	0.00922	$70,093	$367,268	Relatively Low
Maries	0.00087	$48	0.00066	$5,038	$53,466	Very Low
Marion	0.00050	$37	0.00030	$2,278	$39,707	Very Low
Mercer	0.00020	$1	0.00001	$80	$1,572	Very Low
Miller	0.00064	$72	0.00075	$5,686	$78,137	Very Low
Mississippi	0.00488	$2,043	0.13835	$1,051,464	$3,094,704	Relatively Moderate
Moniteau	0.00055	$32	0.00038	$2,854	$34,810	Very Low
Monroe	0.00060	$19	0.00017	$1,289	$20,561	Very Low
Montgomery	0.00089	$70	0.00086	$6,535	$76,293	Very Low
Morgan	0.00047	$63	0.00058	$4,398	$67,306	Very Low
New Madrid	0.00521	$3,571	0.18496	$1,405,663	$4,976,378	Relatively Moderate
Newton	0.00047	$92	0.00088	$6,668	$98,320	Very Low
Nodaway	0.00016	$8	0.00007	$548	$8,775	Very Low
Oregon	0.00221	$178	0.00627	$47,672	$225,992	Relatively Low
Osage	0.00077	$58	0.00069	$5,273	$63,281	Very Low
Ozark	0.00117	$67	0.00159	$12,067	$79,452	Very Low
Pemiscot	0.00547	$3,170	0.18146	$1,379,128	$4,549,194	Relatively Moderate
Perry	0.00285	$941	0.03122	$237,286	$1,178,056	Relatively Low
Pettis	0.00049	$81	0.00066	$5,046	$86,342	Very Low
Phelps	0.00108	$334	0.00654	$49,709	$384,032	Relatively Low
Pike	0.00075	$67	0.00124	$9,439	$76,686	Very Low
Platte	0.00025	$52	0.00037	$2,778	$54,948	Very Low
Polk	0.00053	$78	0.00125	$9,481	$87,701	Very Low
Pulaski	0.00088	$342	0.00396	$30,134	$371,854	Relatively Low
Putnam	0.00022	$3	0.00002	$119	$2,807	Very Low
Ralls	0.00065	$25	0.00020	$1,543	$26,098	Very Low
Randolph	0.00052	$47	0.00048	$3,632	$51,083	Very Low
Ray	0.00032	$20	0.00017	$1,326	$21,171	Very Low
Reynolds	0.00213	$167	0.00585	$44,422	$211,434	Relatively Low
Ripley	0.00294	$430	0.01707	$129,703	$559,701	Relatively Low
St. Charles	0.00155	$4,846	0.12803	$973,022	$5,819,158	Relatively Moderate
St. Clair	0.00042	$13	0.00012	$902	$14,058	Very Low
Ste. Genevieve	0.00244	$484	0.01086	$82,539	$566,307	Relatively Low

County	Annualized Frequency	Expected Annual Loss Buildings (in $ Thousands)	Expected Annual Loss - Fatalities	Expected Annual Loss - Population Equivalence	Expected Annual Loss - Total	Expected Annual Loss Rating
St. Francois	0.00229	$1,400	0.04192	$318,596	$1,718,689	Relatively Low
St. Louis	0.00169	$20,877	0.42760	$3,249,791	$24,126,723	Relatively High
St. Louis, City	0.00222	$11,025	0.22252	$1,691,173	$12,716,223	Relatively Moderate
Saline	0.00042	$36	0.00039	$2,960	$38,836	Very Low
Schuyler	0.00029	$2	0.00002	$129	$2,323	Very Low
Scotland	0.00035	$5	0.00004	$271	$5,556	Very Low
Scott	0.00418	$5,204	0.25006	$1,900,491	$7,104,709	Relatively Moderate
Shannon	0.00190	$154	0.00781	$59,330	$212,909	Relatively Low
Shelby	0.00058	$14	0.00011	$850	$14,920	Very Low
Stoddard	0.00411	$2,655	0.12852	$976,722	$3,631,403	Relatively Moderate
Stone	0.00060	$83	0.00079	$5,967	$88,889	Very Low
Sullivan	0.00024	$3	0.00003	$192	$3,333	Very Low
Taney	0.00080	$189	0.00207	$15,769	$204,934	Relatively Low
Texas	0.00131	$172	0.00337	$25,592	$197,589	Relatively Low
Vernon	0.00051	$33	0.00027	$2,046	$34,923	Very Low
Warren	0.00109	$210	0.00396	$30,115	$240,060	Relatively Low
Washington	0.00179	$265	0.00872	$66,283	$330,864	Relatively Low
Wayne	0.00276	$361	0.01035	$78,675	$440,086	Relatively Low
Webster	0.00076	$124	0.00266	$20,189	$144,159	Relatively Low
Worth	0.00016	$0	0.00000	$20	$467	Very Low
Wright	0.00093	$118	0.00234	$17,775	$135,685	Relatively Low

Table A.12. HAZUS-MH Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Direct Economic Losses Results Summary by County (All values in thousands)

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
St. Louis City	$1,949,201	$6,160,589	$2,539,227	$75,332	5.84	$1,013,089	$384,393	$486,441	$454,429	$13,062,699
St. Louis	$743,887	$2,487,176	$1,080,057	$37,022	6.89	$409,797	$193,220	$239,233	$227,973	$5,418,365
Cape Girardeau	$597,637	$2,140,986	$813,363	$22,777	31.15	$305,430	$119,890	$174,133	$135,755	$4,309,971
Jefferson	$435,917	$1,412,097	$526,453	$11,707	8.31	$239,233	$61,970	$81,642	$83,896	$2,852,915
Scott	$393,622	$1,440,264	$560,141	$22,085	45.43	$201,209	$61,559	$83,504	$78,304	$2,840,689
St. Charles	$369,881	$1,162,593	$449,190	$9,511	3.66	$200,216	$72,356	$93,926	$83,171	$2,440,845
Dunklin	$301,286	$1,037,400	$387,954	$10,944	44.98	$158,495	$43,029	$62,375	$63,834	$2,065,316
Stoddard	$247,347	$878,094	$325,448	$10,685	37.65	$130,329	$29,682	$44,860	$50,290	$1,716,735
New Madrid	$246,570	$896,091	$303,785	$10,619	64.73	$121,245	$25,553	$40,446	$53,425	$1,697,734
Butler	$217,447	$744,680	$290,800	$10,735	23.22	$122,494	$32,442	$50,255	$50,408	$1,519,262
Pemiscot	$205,587	$777,124	$273,217	$6,792	59.84	$109,562	$23,084	$35,869	$44,994	$1,476,230
St. Francois	$172,068	$548,759	$202,485	$6,189	11.66	$100,863	$29,410	$43,291	$39,573	$1,142,637
Mississippi	$140,944	$505,577	$171,275	$3,913	58.01	$74,421	$15,553	$21,429	$30,046	$963,156
Franklin	$129,283	$367,029	$146,775	$6,325	4.35	$70,946	$24,439	$31,243	$26,988	$803,029
Greene	$106,340	$282,704	$101,638	$2,653	1.21	$66,754	$23,549	$32,699	$28,904	$645,241
Perry	$96,805	$307,216	$124,522	$6,226	18.09	$52,059	$12,896	$20,875	$19,112	$639,711
Ste. Genevieve	$73,391	$236,053	$91,675	$3,933	14.31	$39,222	$10,158	$16,311	$14,418	$485,160
Jackson	$85,597	$179,993	$53,610	$1,622	0.30	$47,990	$16,440	$20,654	$22,788	$428,693
Wayne	$57,036	$188,917	$62,927	$1,587	19.57	$36,248	$5,629	$8,523	$12,004	$372,871
Ripley	$54,859	$179,711	$65,791	$2,589	20.73	$34,006	$6,191	$9,758	$10,983	$363,888
Howell	$55,995	$158,220	$59,731	$2,049	6.03	$36,564	$11,636	$16,469	$14,442	$355,107
Bollinger	$51,293	$169,434	$55,111	$1,009	21.32	$30,534	$3,756	$5,080	$9,951	$326,167
Boone	$47,799	$129,199	$44,304	$679	0.96	$29,990	$11,430	$15,490	$14,373	$293,265
Madison	$44,290	$140,643	$52,254	$1,795	16.29	$26,861	$5,610	$8,290	$9,236	$288,979
Cole	$43,457	$120,094	$44,103	$541	1.53	$32,126	$7,001	$14,911	$13,288	$275,521
Phelps	$38,019	$108,793	$40,517	$843	3.10	$24,804	$9,319	$14,269	$10,713	$247,276
Pulaski	$37,007	$98,954	$30,192	$359	2.55	$16,823	$4,313	$5,918	$11,663	$205,229
Washington	$32,398	$98,709	$32,139	$436	7.57	$22,252	$3,321	$5,511	$7,078	$201,844
Taney	$27,344	$81,222	$26,710	$427	1.77	$17,890	$11,503	$14,074	$12,376	$191,546
Iron	$28,245	$89,400	$31,563	$931	12.02	$17,368	$3,032	$4,929	$6,510	$181,978
Crawford	$27,361	$77,077	$28,333	$904	4.37	$17,082	$4,787	$6,210	$6,205	$167,959

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Lincoln	$27,994	$76,171	$26,846	$605	2.21	$17,350	$3,618	$5,112	$5,630	$163,327
Camden	$25,407	$75,023	$23,467	$351	1.21	$15,754	$4,940	$6,219	$7,906	$159,068
Christian	$27,084	$75,350	$25,272	$573	1.32	$16,278	$3,693	$4,400	$6,180	$158,829
Oregon	$24,137	$72,964	$24,754	$447	10.90	$15,933	$3,444	$4,615	$5,410	$151,703
Texas	$23,223	$62,179	$22,454	$639	3.72	$15,051	$3,764	$5,474	$5,464	$138,246
Carter	$19,483	$63,654	$21,883	$695	16.01	$12,804	$3,052	$4,158	$4,515	$130,244
Reynolds	$19,472	$62,211	$21,814	$829	12.20	$12,608	$2,126	$4,132	$4,495	$127,687
Clay	$25,868	$52,452	$15,023	$474	0.28	$13,597	$3,751	$4,842	$5,989	$121,996
Warren	$20,203	$57,360	$21,109	$607	2.23	$12,135	$2,777	$3,508	$4,219	$121,919
Dent	$18,897	$52,441	$19,313	$513	4.91	$12,100	$3,244	$4,674	$4,095	$115,277
Jasper	$19,922	$45,641	$15,083	$527	0.54	$12,951	$4,334	$5,902	$5,320	$109,681
Laclede	$15,737	$39,201	$13,915	$528	1.71	$10,311	$3,080	$3,950	$4,089	$90,812
Callaway	$15,892	$41,449	$13,755	$296	1.30	$9,598	$2,252	$3,189	$3,876	$90,307
Shannon	$13,888	$43,013	$14,536	$330	8.38	$9,252	$1,358	$2,230	$3,344	$87,951
Stone	$14,359	$40,589	$12,805	$135	1.40	$9,678	$1,891	$2,461	$3,604	$85,522
Gasconade	$12,743	$34,070	$12,792	$382	2.48	$8,034	$2,282	$3,146	$2,855	$76,305
Webster	$12,530	$33,048	$11,254	$271	1.64	$8,408	$1,746	$2,188	$2,931	$72,376
Wright	$12,043	$30,999	$11,141	$333	2.69	$8,262	$2,096	$2,842	$2,914	$70,630
Barry	$10,373	$25,784	$9,524	$471	0.97	$6,844	$1,520	$2,266	$2,343	$59,125
Newton	$10,400	$23,237	$7,455	$243	0.61	$6,695	$1,813	$2,592	$2,581	$55,016
Marion	$8,643	$22,001	$7,606	$195	0.95	$5,458	$2,224	$3,050	$2,482	$51,658
Miller	$8,681	$22,383	$7,412	$187	1.29	$5,847	$1,528	$1,852	$2,189	$50,078
Lawrence	$8,919	$21,698	$7,374	$264	0.88	$5,744	$1,262	$1,788	$2,115	$49,165
Cass	$10,550	$22,676	$5,872	$111	0.30	$5,612	$933	$1,276	$2,125	$49,155
Ozark	$8,178	$22,834	$7,801	$190	3.35	$5,651	$836	$1,368	$1,921	$48,779
Osage	$8,207	$21,758	$8,325	$408	1.86	$4,981	$920	$1,450	$1,614	$47,663
Pettis	$8,569	$19,374	$6,821	$267	0.63	$5,430	$1,539	$2,237	$2,228	$46,464
Platte	$9,435	$20,250	$5,295	$108	0.26	$4,819	$1,290	$1,588	$2,327	$45,111
Johnson	$8,031	$19,889	$6,809	$115	0.46	$5,590	$1,064	$1,585	$1,998	$45,082
Audrain	$7,885	$19,102	$6,903	$227	1.00	$4,908	$1,414	$2,176	$1,879	$44,495
Buchanan	$8,580	$16,843	$5,189	$199	0.24	$5,166	$2,025	$2,853	$2,173	$43,028
Polk	$7,744	$18,811	$6,147	$148	0.98	$5,063	$1,163	$1,721	$1,911	$42,707
Douglas	$7,074	$19,431	$6,529	$151	2.53	$5,119	$830	$1,149	$1,671	$41,953

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Morgan	$7,694	$18,730	$5,831	$140	0.92	$5,133	$1,024	$1,305	$1,794	$41,651
Pike	$7,013	$17,351	$6,186	$174	1.31	$4,375	$1,150	$1,618	$1,836	$39,703
Montgomery	$6,777	$16,153	$5,990	$282	1.64	$4,076	$907	$1,247	$1,536	$36,967
Maries	$5,576	$14,984	$5,419	$178	2.15	$3,465	$561	$790	$1,077	$32,050
Benton	$5,156	$12,675	$3,594	$48	0.72	$3,522	$586	$733	$1,139	$27,455
Dallas	$4,739	$11,846	$3,743	$89	1.22	$3,232	$501	$675	$1,043	$25,868
Henry	$4,504	$9,915	$3,347	$135	0.57	$2,723	$709	$1,059	$1,098	$23,491
Randolph	$4,277	$9,777	$3,143	$101	0.58	$2,744	$800	$1,097	$1,103	$23,041
Moniteau	$4,192	$10,239	$3,495	$120	0.96	$2,489	$454	$625	$883	$22,496
Cooper	$4,182	$9,485	$3,163	$121	0.76	$2,443	$608	$876	$1,041	$21,917
Lafayette	$4,625	$9,384	$2,730	$76	0.36	$2,549	$544	$742	$1,017	$21,668
Saline	$3,685	$8,283	$2,585	$78	0.49	$2,257	$611	$806	$956	$19,261
Ralls	$3,325	$8,067	$2,776	$121	0.99	$1,981	$302	$429	$666	$17,668
McDonald	$3,280	$7,802	$2,252	$59	0.66	$2,245	$289	$412	$708	$17,047
Vernon	$3,000	$6,737	$2,131	$59	0.43	$1,984	$518	$798	$754	$15,981
Cedar	$2,513	$5,822	$1,841	$60	0.64	$1,754	$441	$632	$651	$13,715
Barton	$2,531	$5,399	$1,998	$75	0.56	$1,582	$373	$524	$537	$13,019
Adair	$2,456	$5,252	$1,421	$26	0.30	$1,559	$512	$775	$841	$12,841
Hickory	$2,281	$5,461	$1,479	$19	0.89	$1,764	$181	$287	$501	$11,974
Monroe	$2,187	$5,058	$1,621	$55	0.74	$1,408	$312	$418	$486	$11,545
Ray	$2,485	$5,114	$1,346	$26	0.30	$1,401	$231	$317	$502	$11,421
Macon	$2,229	$4,725	$1,408	$34	0.43	$1,450	$399	$588	$569	$11,401
Howard	$2,257	$4,984	$1,548	$40	0.67	$1,327	$241	$365	$512	$11,274
Bates	$2,137	$4,491	$1,315	$28	0.40	$1,346	$225	$345	$463	$10,349
St. Clair	$1,837	$4,177	$1,255	$19	0.64	$1,309	$220	$385	$400	$9,602
Dade	$1,727	$3,985	$1,310	$51	0.77	$1,147	$229	$307	$394	$9,149
Linn	$1,848	$3,661	$1,086	$29	0.36	$1,145	$298	$411	$419	$8,898
Lewis	$1,750	$3,777	$1,131	$40	0.56	$1,026	$261	$313	$421	$8,719
Livingston	$1,744	$3,341	$984	$45	0.30	$1,033	$325	$441	$458	$8,371
Carroll	$1,588	$3,304	$1,070	$45	0.41	$981	$211	$381	$349	$7,931
Chariton	$1,632	$3,358	$1,031	$30	0.53	$962	$198	$281	$364	$7,855
Clinton	$1,721	$3,410	$813	$17	0.22	$979	$206	$274	$382	$7,801
Shelby	$1,430	$2,980	$1,004	$33	0.56	$876	$216	$265	$322	$7,125

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Nodaway	$1,535	$2,783	$684	$19	0.18	$817	$205	$293	$423	$6,759
Grundy	$1,179	$2,215	$599	$17	0.29	$720	$154	$260	$299	$5,444
Andrew	$1,172	$2,194	$513	$9	0.20	$663	$137	$169	$257	$5,114
Clark	$890	$1,842	$515	$12	0.38	$580	$133	$179	$206	$4,357
Caldwell	$895	$1,677	$410	$8	0.26	$545	$73	$115	$189	$3,911
Daviess	$859	$1,628	$441	$24	0.26	$521	$94	$143	$172	$3,882
Harrison	$813	$1,479	$378	$7	0.22	$520	$167	$224	$209	$3,797
DeKalb	$829	$1,511	$347	$6	0.21	$436	$85	$112	$225	$3,550
Sullivan	$613	$1,168	$326	$13	0.29	$401	$80	$139	$145	$2,886
Scotland	$608	$1,146	$326	$10	0.32	$365	$81	$136	$147	$2,818
Knox	$574	$1,101	$312	$8	0.38	$360	$74	$103	$134	$2,666
Gentry	$519	$875	$230	$7	0.20	$324	$74	$117	$127	$2,273
Holt	$499	$881	$252	$8	0.22	$301	$87	$103	$115	$2,246
Atchison	$508	$873	$236	$6	0.17	$293	$68	$93	$118	$2,194
Putnam	$445	$793	$190	$5	0.23	$289	$52	$74	$104	$1,953
Schuyler	$358	$664	$163	$3	0.25	$229	$34	$66	$89	$1,607
Mercer	$293	$539	$121	$2	0.21	$191	$27	$41	$69	$1,282
Worth	$170	$299	$68	$1	0.17	$101	$12	$25	$38	$715
Total	$7,659,201	$24,752,079	$9,533,725	$287,656		$4,184,856	$1,357,240	$1,833,524	$1,789,811	$51,398,085

Source: Hazus / WSP

Land Subsidence/Sinkhole– State Vulnerability Tables

Table A.13 provides the count of sinkholes, mines, and caves per County.

Table A.13. Sinkhole, Mine, and Cave Counts per County

County	# of Sinkholes Per County	# of Mines Per County	# of Caves Per County
Adair	0	124	0
Andrew	1	96	0
Atchison	0	14	0
Audrain	5	94	0
Barry	90	210	216
Barton	1	133	9
Bates	0	184	5
Benton	7	172	38
Bollinger	5	130	6
Boone	437	267	118
Buchanan	0	80	0
Butler	6	107	5
Caldwell	0	39	0
Callaway	7	454	19
Camden	91	185	232
Cape Girardeau	477	90	70
Carroll	0	74	0
Carter	73	101	84
Cass	0	91	3
Cedar	12	84	22
Chariton	0	85	0
Christian	662	250	373
Clark	2	43	0
Clay	8	133	2
Clinton	0	85	0
Cole	9	260	18
Cooper	243	134	59
Crawford	92	581	221
Dade	96	152	78
Dallas	23	44	20
Daviess	0	79	0
Dekalb	0	58	0
Dent	492	173	93
Douglas	106	78	166
Dunklin	0	10	0
Franklin	36	820	48
Gasconade	8	1457	10
Gentry	2	86	0
Greene	1470	378	308
Grundy	0	55	0
Harrison	0	84	0
Henry	2	232	32
Livingston	0	107	0
Macon	1	205	0
Madison	5	319	13
Maries	16	286	43
Marion	59	48	12
McDonald	13	48	117
Mercer	0	74	0
Miller	10	969	55
Mississippi	0	2	0
Moniteau	188	378	37
Monroe	0	76	1
Montgomery	5	342	7
Morgan	7	700	30
New Madrid	0	29	0
Newton	46	2090	34
Nodaway	0	84	0
Oregon	492	192	183
Osage	8	495	27
Ozark	124	146	75
Pemiscot	0	8	0
Perry	2707	83	684
Pettis	12	95	5
Phelps	245	440	174
Pike	135	89	38
Platte	0	137	1
Polk	91	53	55
Pulaski	138	86	371
Putnam	0	92	0
Ralls	200	114	62
Randolph	0	255	6
Ray	2	133	0
Reynolds	67	112	83
Ripley	35	76	43
Saline	27	117	5
Schuyler	0	14	0
Scotland	0	11	0
Scott	14	64	4
Shannon	846	214	578
Shelby	3	31	3
St Charles	69	74	26
St Clair	10	208	65
St Francois	132	602	15

County	# of Sinkholes Per County	# of Mines Per County	# of Caves Per County
Hickory	26	147	46
Holt	0	40	0
Howard	12	78	1
Howell	1385	339	66
Iron	10	232	18
Jackson	8	231	7
Jasper	156	5940	55
Jefferson	54	423	180
Johnson	0	143	1
Knox	1	20	0
Laclede	334	79	101
Lafayette	3	203	1
Lawrence	93	1245	31
Lewis	2	37	0
Lincoln	293	70	41
Linn	0	44	0

County	# of Sinkholes Per County	# of Mines Per County	# of Caves Per County
St Louis	1462	169	142
St Louis City	117	108	28
Ste Genevieve	783	172	155
Stoddard	0	197	3
Stone	32	63	349
Sullivan	0	53	0
Taney	69	79	217
Texas	483	146	280
Vernon	0	261	62
Warren	8	414	19
Washington	22	1856	166
Wayne	19	425	36
Webster	58	118	100
Worth	0	28	0
Wright	363	126	43
Grand Total	**15,963**	**31,190**	**7255**

Table A.14 provides the factors considered for drought and the ranges for the rating values assigned.

Table A.14. Sinkhole Rating Values

Factor	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Sinkholes per county	0	1 – 156	157-363	364-846	847-2,707

Table A.15 presents the number of structures (MSDIS structures or LiDAR-derived RiskMAP Footprints) that are located within sinkhole areas or within a buffered distance of 50 feet of sinkholes. Population is based upon the average household size and is applied to the residential structure count.

Table A.15. Number and Value of Structures with Population Potentially Impacted by County (Note that Population affected is zero when residential structure impact is not predicted)

County	Property Type	# of Structures in Sinkhole Area	Sum of Exposure Values	Population
Barry	Agriculture	3	$3,807	
Barry Total		**3**	**$3,807**	**0.00**
Boone	Agriculture	9	$96,186	
Boone	Residential	32	$9,750,142	76.48
Boone Total		**41**	**$9,846,328**	**76.48**
Cape Girardeau	Agriculture	12	$66,531	
Cape Girardeau	Commercial	3	$5,757,601	
Cape Girardeau	Residential	44	$9,355,103	111.76
Cape Girardeau Total		**59**	**$15,179,235**	**111.76**
Carter	Agriculture	1	$1,342	

County	Property Type	# of Structures in Sinkhole Area	Sum of Exposure Values	Population
Carter Total		**1**	**$1,342**	**0.00**
Christian	Agriculture	26	$98,298	
Christian	Commercial	15	$7,082,261	
Christian	Industrial	5	$3,469,592	
Christian	Residential	196	$29,754,998	527.24
Christian Total		**242**	**$40,405,148**	**527.24**
Cooper	Agriculture	1	$5,791	
Cooper Total		**1**	**$5,791**	**0.00**
Crawford	Agriculture	3	$10,257	
Crawford	Residential	1	$108,718	2.47
Crawford Total		**4**	**$118,974**	**2.47**
Dent	Agriculture	12	$11,334	
Dent	Commercial	1	$278,806	
Dent	Residential	4	$524,717	9.64
Dent Total		**17**	**$814,856**	**9.64**
Douglas	Agriculture	1	$1,058	
Douglas Total		**1**	**$1,058**	**0.00**
Franklin	Residential	1	$225,290	2.50
Franklin Total		**1**	**$225,290**	**2.50**
Greene	Agriculture	87	$556,906	
Greene	Commercial	37	$25,686,969	
Greene	Industrial	2	$3,916,848	
Greene	Residential	538	$131,855,072	1194.36
Greene Total		**664**	**$162,015,795**	**1194.36**
Howell	Agriculture	25	$52,743	
Howell	Commercial	6	$2,559,558	
Howell	Industrial	2	$789,992	
Howell	Residential	31	$4,000,231	77.19
Howell Total		**64**	**$7,402,524**	**77.19**
Jasper	Residential	8	$1,587,083	20.56
Jasper Total		**8**	**$1,587,083**	**20.56**
Jefferson	Residential	3	$675,424	7.89
Jefferson Total		**3**	**$675,424**	**7.89**
Laclede	Agriculture	3	$9,240	
Laclede	Industrial	1	$740,533	
Laclede	Residential	38	$7,079,374	94.62
Laclede Total		**42**	**$7,829,147**	**94.62**
Lawrence	Residential	6	$1,108,622	15.24
Lawrence Total		**6**	**$1,108,622**	**15.24**
Lincoln	Agriculture	6	$18,217	
Lincoln	Residential	3	$727,496	8.67
Lincoln Total		**9**	**$745,713**	**8.67**

County	Property Type	# of Structures in Sinkhole Area	Sum of Exposure Values	Population
Moniteau	Agriculture	12	$37,570	
Moniteau	Residential	6	$1,474,473	16.20
Moniteau Total		**18**	**$1,512,043**	**16.20**
Montgomery	Agriculture	22	$29,927	
Montgomery	Residential	1	$87,737	2.22
Montgomery Total		**23**	**$117,664**	**2.22**
Newton	Commercial	1	$444,482	
Newton Total		**1**	**$444,482**	**0.00**
Oregon	Agriculture	4	$4,422	
Oregon	Residential	6	$563,739	14.82
Oregon Total		**10**	**$568,162**	**14.82**
Ozark	Agriculture	1	$881	
Ozark Total		**1**	**$881**	**0.00**
Perry	Agriculture	141	$838,758	
Perry	Commercial	2	$2,736,696	
Perry	Residential	282	$33,504,000	702.18
Perry Total		**425**	**$37,079,454**	**702.18**
Phelps	Commercial	1	$761,325	
Phelps	Residential	4	$582,001	9.24
Phelps Total		**5**	**$1,343,327**	**9.24**
Polk	Residential	4	$731,259	10.32
Polk Total		**4**	**$731,259**	**10.32**
Pulaski	Government	8	$81,752	
Pulaski	Residential	7	$2,805,565	19.88
Pulaski Total		**15**	**$2,887,317**	**19.88**
Ralls	Agriculture	2	$5,744	
Ralls	Residential	4	$746,497	10.04
Ralls Total		**6**	**$752,241**	**10.04**
Saline	Residential	1	$199,768	2.61
Saline Total		**1**	**$199,768**	**2.61**
Scott	Residential	2	$410,573	5.00
Scott Total		**2**	**$410,573**	**5.00**
Shannon	Agriculture	6	$10,121	
Shannon	Residential	2	$160,295	5.28
Shannon Total		**8**	**$170,416**	**5.28**
St. Charles	Commercial	9	$7,941,971	
St. Charles	Residential	121	$39,046,597	319.44
St. Charles Total		**130**	**$46,988,569**	**319.44**
St. Francois	Agriculture	3	$28,017	
St. Francois	Commercial	1	$419,237	
St. Francois	Residential	2	$463,431	4.78
St. Francois Total		**6**	**$910,686**	**4.78**

County	Property Type	# of Structures in Sinkhole Area	Sum of Exposure Values	Population
St. Louis	Agriculture	6	$1,161,378	
St. Louis	Commercial	177	$80,829,669	
St. Louis	Education	4	$7,343,150	
St. Louis	Residential	2496	$656,089,076	6015.36
St. Louis Total		**2683**	**$745,423,272**	**6015.36**
St. Louis, City	Commercial	164	$154,455,672	
St. Louis, City	Education	12	$14,390,803	
St. Louis, City	Government	2	$3,553,351	
St. Louis, City	Industrial	11	$9,626,369	
St. Louis, City	Residential	2198	$473,071,340	4615.80
St. Louis, City Total		**2387**	**$655,097,534**	**4615.80**
Ste. Genevieve	Agriculture	76	$183,828	
Ste. Genevieve	Commercial	14	$14,505,351	
Ste. Genevieve	Industrial	4	$2,893,780	
Ste. Genevieve	Residential	48	$10,363,870	118.56
Ste. Genevieve Total		**142**	**$27,946,829**	**118.56**
Stone	Agriculture	1	$1,704	
Stone	Commercial	4	$369,201	
Stone	Residential	9	$1,227,824	21.96
Stone Total		**14**	**$1,598,729**	**21.96**
Taney	Agriculture	1	$3,721	
Taney	Commercial	4	$1,145,935	
Taney	Residential	5	$1,296,842	12.00
Taney Total		**10**	**$2,446,498**	**12.00**
Texas	Agriculture	5	$7,233	
Texas	Commercial	1	$210,891	
Texas	Residential	16	$1,056,883	39.84
Texas Total		**22**	**$1,275,007**	**39.84**
Webster	Residential	23	$2,310,087	63.94
Webster Total		**23**	**$2,310,087**	**63.94**
Wright	Agriculture	16	$39,667	
Wright	Residential	4	$654,345	10.20
Wright Total		**20**	**$694,012**	**10.20**
TOTAL		**7,122**	**$1,778,874,949**	**14,168**

Wildfire – State Vulnerability Tables

Table A.16 presents the statistical data on historical wildfire events and the likelihood of occurrence.

Table A.16. Statistical Data for Wildfire Hazard

County	Number of Wildfires 2004-2021	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Adair	176	9.8	1,915.68	106.4
Andrew	600	33.3	5,028.12	279.3
Atchison	298	16.6	2,558.03	142.1
Audrain	124	6.9	578.55	32.1
Barry	865	48.1	6,973.12	387.4
Barton	214	11.9	6,216.88	345.4
Bates	339	18.8	5,258.25	292.1
Benton	1458	81.0	27,579.55	1532.2
Bollinger	518	28.8	3,763.80	209.1
Boone	11	0.6	71.86	4.0
Buchanan	565	31.4	3,315.24	184.2
Butler	1552	86.2	4,552.59	252.9
Caldwell	188	10.4	5,555.18	308.6
Callaway	758	42.1	5,513.47	306.3
Camden	3041	168.9	77,329.66	4296.1
Cape Girardeau	457	25.4	3,118.18	173.2
Carroll	485	26.9	15,427.61	857.1
Carter	144	8.0	6,961.98	386.8
Cass	413	22.9	2,498.36	138.8
Cedar	492	27.3	7,862.68	436.8
Chariton	299	16.6	5,502.54	305.7
Christian	306	17.0	2,735.57	152.0
Clark	309	17.2	3,327.29	184.8
Clay	282	15.7	1,342.15	74.6
Clinton	744	41.3	6,854.19	380.8
Cole	232	12.9	969.58	53.9
Cooper	638	35.4	3,679.59	204.4
Crawford	1202	66.8	11,376.72	632.0
Dade	648	36.0	7,397.75	411.0
Dallas	798	44.3	42,370.21	2353.9
Daviess	426	23.7	7,066.82	392.6
Dekalb	488	27.1	11,038.27	613.2
Dent	543	30.2	11,257.01	625.4
Douglas	561	31.2	13,828.92	768.3
Dunklin	22	1.2	37.60	2.1
Franklin	962	53.4	3,428.18	190.5
Gasconade	100	5.6	2,086.37	115.9
Gentry	316	17.6	8,291.91	460.7
Greene	1111	61.7	5,726.30	318.1
Grundy	190	10.6	2,267.15	126.0
Harrison	295	16.4	10,557.25	586.5
Henry	1235	68.6	28,011.32	1556.2

County	Number of Wildfires 2004-2021	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Hickory	286	15.9	5,393.61	299.6
Holt	148	8.2	2,901.38	161.2
Howard	141	7.8	2,303.75	128.0
Howell	1165	64.7	15,523.91	862.4
Iron	167	9.3	7,761.05	431.2
Jackson	450	25.0	636.57	35.4
Jasper	606	33.7	3,774.67	209.7
Jefferson	1261	70.1	3,524.92	195.8
Johnson	997	55.4	5,179.71	287.8
Knox	38	2.1	870.84	48.4
Laclede	599	33.3	25,206.44	1400.4
Lafayette	345	19.2	1,885.69	104.8
Lawrence	854	47.4	5,205.93	289.2
Lewis	238	13.2	1,938.12	107.7
Lincoln	458	25.4	2,395.96	133.1
Linn	193	10.7	4,781.56	265.6
Livingston	213	11.8	5,623.90	312.4
Macon	261	14.5	4,717.79	262.1
Madison	335	18.6	1,919.63	106.6
Maries	273	15.2	4,522.85	251.3
Marion	209	11.6	1,993.37	110.7
McDonald	402	22.3	3,519.71	195.5
Mercer	105	5.8	2,432.61	135.1
Miller	816	45.3	8,438.01	468.8
Mississippi	236	13.1	1,088.13	60.5
Moniteau	542	30.1	3,874.84	215.3
Monroe	318	17.7	4,517.73	251.0
Montgomery	240	13.3	1,774.69	98.6
Morgan	1143	63.5	15,300.85	850.0
New Madrid	110	6.1	184.17	10.2
Newton	2328	129.3	9,201.22	511.2
Nodaway	526	29.2	7,664.56	425.8
Oregon	813	45.2	10,853.44	603.0
Osage	259	14.4	1,579.13	87.7
Ozark	536	29.8	14,277.56	793.2
Pemiscot	140	7.8	551.99	30.7
Perry	44	2.4	575.90	32.0
Pettis	247	13.7	2,703.44	150.2
Phelps	535	29.7	4,250.67	236.1
Pike	257	14.3	3,168.61	176.0
Platte	90	5.0	1,103.75	61.3
Polk	786	43.7	5,953.78	330.8
Pulaski	530	29.4	5,221.02	290.1
Putnam	157	8.7	2,246.63	124.8
Ralls	126	7.0	2,630.08	146.1
Randolph	441	24.5	4,674.89	259.7
Ray	486	27.0	7,890.48	438.4

County	Number of Wildfires 2004-2021	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Reynolds	716	39.8	28,705.61	1594.8
Ripley	548	30.4	6,937.55	385.4
Saline	143	7.9	1,870.46	103.9
Schuyler	76	4.2	1,532.86	85.2
Scotland	200	11.1	3,442.72	191.3
Scott	384	21.3	2,824.18	156.9
Shannon	629	34.9	20,131.75	1118.4
Shelby	144	8.0	2,229.74	123.9
St. Charles	194	10.8	984.74	54.7
St. Clair	756	42.0	26,292.32	1460.7
St. Francois	1293	71.8	9,736.48	540.9
St. Genevieve	420	23.3	2,085.83	115.9
St. Louis*	82	4.6	165.26	9.2
St. Louis City*	9	0.5	1.95	0.1
Stoddard	567	31.5	2,899.68	161.1
Stone	610	33.9	5,474.32	304.1
Sullivan	115	6.4	7,091.62	394.0
Taney	1119	62.2	11,092.44	616.2
Texas	923	51.3	11,710.08	650.6
Vernon	354	19.7	10,150.88	563.9
Warren	205	11.4	1,240.46	68.9
Washington	1641	91.2	35,398.89	1966.6
Wayne	375	20.8	8,867.46	492.6
Webster	745	41.4	6,089.71	338.3
Worth	182	10.1	8,345.77	463.7
Wright	717	39.8	6,191.95	344.0
Totals	**59,002**	**3,278**	**836,466**	**46,470**

Table A.17 presents the estimated numbers and values of structures by property type and by county that are vulnerable to wildfire. Population data has been calculated for residential structures based upon the average household size per county.

Table A.17. Estimated Numbers and Values of Structures and Population Vulnerable to Wildfire

County	Property Type	Number of Structures	Value of Structures	Population
Adair		5238	$1,140,474,381	10983
	Agriculture	348	$817,142	
	Commercial	320	$151,882,016	
	Education	30	$65,056,731	
	Government	6	$2,943,091	
	Industrial	51	$24,258,884	
	Residential	4483	$895,516,518	10983
Andrew		**812**	**$181,732,735**	**1700**
	Residential	664	$159,458,959	1700

	Industrial	1	$472,792	
	Government	3	$400,629	
	Commercial	61	$20,097,381	
	Agriculture	82	$534,801	
	Education	1	$768,174	
Atchison		**75**	**$6,531,729**	**62**
	Agriculture	41	$144,086	
	Government	1	$370,000	
	Industrial	2	$165,048	
	Residential	31	$5,852,596	62
Audrain		**266**	**$54,236,172**	**479**
	Industrial	2	$1,175,730	
	Residential	187	$42,117,367	479
	Government	6	$2,572,364	
	Commercial	14	$7,220,376	
	Agriculture	56	$151,385	
	Education	1	$998,950	
Barry		**8652**	**$843,497,700**	**13927**
	Agriculture	3008	$3,817,479	
	Commercial	231	$68,665,338	
	Government	13	$2,367,542	
	Industrial	2	$9,585,515	
	Residential	5398	$759,061,825	13927
Barton		**232**	**$24,540,635**	**273**
	Agriculture	111	$391,351	
	Commercial	6	$2,153,107	
	Residential	115	$21,996,177	273
Bates		**49**	**$8,511,476**	**68**
	Agriculture	21	$95,778	
	Residential	28	$8,415,698	68
Benton		**7254**	**$1,416,341,399**	**15922**
	Industrial	3	$5,782,909	
	Residential	6634	$1,359,384,629	15922
	Government	8	$3,578,133	
	Commercial	514	$43,615,161	
	Agriculture	93	$515,567	
	Education	2	$3,465,000	
Bollinger		**3207**	**$310,364,266**	**5646**
	Agriculture	974	$1,294,051	
	Commercial	69	$37,829,116	
	Education	6	$7,998,000	
	Government	2	$5,124,667	
	Industrial	1	$4,733,000	

	Residential	2155	$253,385,432	5646
Boone		**16670**	**$4,665,103,926**	**33482**
	Residential	14009	$4,268,429,302	33482
	Industrial	17	$45,701,987	
	Government	9	$11,596,392	
	Agriculture	2495	$26,664,987	
	Commercial	115	$276,686,257	
	Education	25	$36,025,000	
Buchanan		**6868**	**$1,851,668,695**	**14346**
	Residential	5693	$1,470,354,595	14346
	Industrial	51	$27,552,985	
	Government	2	$732,894	
	Commercial	272	$343,108,477	
	Agriculture	845	$5,208,077	
	Education	5	$4,711,667	
Butler		**8280**	**$1,442,664,694**	**16568**
	Agriculture	1362	$11,858,931	
	Commercial	319	$164,340,948	
	Education	8	$6,896,857	
	Government	5	$4,650,814	
	Industrial	63	$36,715,431	
	Residential	6523	$1,218,201,713	16568
Caldwell		**83**	**$6,154,684**	**61**
	Agriculture	58	$124,608	
	Residential	25	$6,030,076	61
Callaway		**7002**	**$1,594,693,484**	**15176**
	Industrial	13	$6,546,810	
	Residential	5928	$1,474,413,616	15176
	Government	19	$2,670,085	
	Commercial	89	$105,800,233	
	Education	1	$629,728	
	Agriculture	952	$4,633,012	
Camden		**27175**	**$6,850,197,593**	**67259**
	Agriculture	587	$2,800,719	
	Commercial	2361	$104,638,938	
	Education	15	$22,920,750	
	Government	29	$15,744,633	
	Industrial	162	$123,076,125	
	Residential	24021	$6,581,016,429	67259
Cape Girardeau		**3671**	**$623,544,321**	**6998**
	Agriculture	902	$5,000,922	
	Commercial	12	$23,030,406	
	Government	2	$9,756,000	

	Residential	2755	$585,756,993	6998
Carroll		**48**	**$12,398,922**	**82**
	Government	5	$4,164,216	
	Residential	33	$7,792,935	82
	Agriculture	9	$31,469	
	Commercial	1	$410,302	
Carter		**2731**	**$268,259,519**	**6259**
	Agriculture	282	$378,453	
	Commercial	43	$35,242,948	
	Education	14	$5,145,280	
	Government	1	$3,465,500	
	Industrial	2	$1,621,185	
	Residential	2389	$222,406,153	6259
Cass		**678**	**$129,066,079**	**1050**
	Residential	407	$123,689,972	1050
	Agriculture	261	$1,047,105	
	Commercial	10	$4,329,003	
Cedar		**3994**	**$219,730,659**	**8508**
	Agriculture	363	$1,002,338	
	Commercial	25	$12,003,908	
	Education	12	$1,985,434	
	Government	2	$828,615	
	Industrial	2	$11,980,000	
	Residential	3590	$191,930,363	8508
Chariton		**295**	**$50,626,914**	**672**
	Residential	249	$45,928,230	672
	Agriculture	31	$109,971	
	Commercial	15	$4,588,713	
Christian		**8683**	**$1,125,063,053**	**17975**
	Agriculture	1787	$6,756,063	
	Commercial	177	$83,570,682	
	Education	15	$14,709,403	
	Government	18	$2,848,708	
	Industrial	4	$2,775,673	
	Residential	6682	$1,014,402,524	17975
Clark		**512**	**$64,932,118**	**703**
	Agriculture	230	$475,896	
	Commercial	3	$1,225,554	
	Residential	279	$63,230,668	703
Clay		**1857**	**$595,578,245**	**4545**
	Residential	1728	$569,225,682	4545
	Industrial	1	$1,580,093	
	Education	1	$1,298,663	

	Commercial	18	$22,314,136	
	Agriculture	109	$1,159,671	
Clinton		**166**	**$38,288,569**	**348**
	Agriculture	20	$78,583	
	Commercial	4	$1,351,275	
	Residential	142	$36,858,711	348
Cole		**6440**	**$2,042,673,022**	**13399**
	Agriculture	741	$5,116,881	
	Commercial	24	$90,802,050	
	Education	1	$1,215,374	
	Government	6	$99,805,982	
	Industrial	38	$38,897,213	
	Residential	5630	$1,806,835,523	13399
Cooper		**760**	**$166,824,609**	**1642**
	Government	4	$845,477	
	Industrial	2	$3,019,692	
	Agriculture	69	$399,546	
	Commercial	31	$15,171,647	
	Residential	654	$147,388,246	1642
Crawford		**13329**	**$1,519,195,711**	**28035**
	Industrial	92	$94,517,960	
	Government	26	$7,940,263	
	Residential	11350	$1,233,944,603	28035
	Commercial	589	$162,170,930	
	Agriculture	1261	$4,311,155	
	Education	11	$16,310,800	
Dade		**648**	**$71,848,408**	**1285**
	Agriculture	107	$334,225	
	Commercial	8	$2,190,258	
	Residential	533	$69,323,925	1285
Dallas		**2664**	**$237,861,799**	**3670**
	Agriculture	1211	$1,516,550	
	Commercial	47	$15,001,195	
	Government	8	$934,500	
	Industrial	8	$4,696,125	
	Residential	1390	$215,713,430	3670
Daviess		**117**	**$10,960,841**	**160**
	Agriculture	53	$71,041	
	Commercial	4	$403,304	
	Residential	60	$10,486,497	160
Dekalb		**46**	**$11,209,435**	**98**
	Commercial	2	$657,860	
	Residential	41	$10,537,122	98

	Agriculture	3	$14,453	
Dent		**2311**	**$207,897,063**	**3256**
	Agriculture	867	$818,864	
	Commercial	79	$22,025,651	
	Education	1	$1,441,222	
	Industrial	13	$6,388,224	
	Residential	1351	$177,223,101	3256
Douglas		**2092**	**$131,929,403**	**3634**
	Government	3	$635,600	
	Agriculture	638	$675,219	
	Commercial	19	$4,687,359	
	Industrial	18	$9,287,654	
	Residential	1414	$116,643,571	3634
Dunklin		**553**	**$61,989,285**	**1223**
	Agriculture	36	$712,521	
	Government	1	$654,214	
	Residential	516	$60,622,549	1223
Franklin		**37240**	**$7,708,721,362**	**70828**
	Industrial	230	$457,475,260	
	Residential	28331	$6,382,676,894	70828
	Government	78	$40,630,200	
	Education	77	$75,564,144	
	Commercial	1523	$727,219,763	
	Agriculture	7001	$25,155,102	
Gasconade		**3547**	**$759,278,320**	**6347**
	Agriculture	617	$1,885,297	
	Commercial	215	$127,291,737	
	Education	12	$16,822,345	
	Government	14	$7,456,313	
	Industrial	22	$39,777,467	
	Residential	2667	$566,045,161	6347
Gentry		**15**	**$931,713**	**13**
	Residential	5	$891,514	13
	Agriculture	10	$40,199	
Greene		**10926**	**$1,845,698,784**	**15411**
	Agriculture	3825	$24,484,657	
	Commercial	117	$81,226,360	
	Government	28	$11,198,245	
	Industrial	14	$27,417,935	
	Residential	6942	$1,701,371,585	15411
Grundy		**1134**	**$212,077,818**	**2332**
	Residential	948	$190,469,663	2332
	Industrial	1	$305,949	

	Government	7	$1,915,487	
	Agriculture	119	$318,805	
	Commercial	56	$16,146,485	
	Education	3	$2,921,429	
Harrison		**115**	**$10,354,601**	**116**
	Agriculture	65	$160,739	
	Commercial	2	$1,062,923	
	Residential	48	$9,130,939	116
Henry		**4236**	**$781,447,031**	**7254**
	Agriculture	867	$3,321,552	
	Commercial	194	$86,834,753	
	Education	6	$8,454,250	
	Government	6	$2,465,906	
	Industrial	9	$10,743,364	
	Residential	3154	$669,627,205	7254
Hickory		**6995**	**$448,954,006**	**15596**
	Industrial	1	$628,368	
	Government	16	$2,809,946	
	Residential	6665	$421,909,119	15596
	Commercial	249	$20,157,022	
	Agriculture	58	$195,551	
	Education	6	$3,254,000	
Holt		**286**	**$20,737,687**	**419**
	Agriculture	84	$283,890	
	Commercial	3	$742,168	
	Government	1	$93,191	
	Industrial	2	$390,038	
	Residential	196	$19,228,399	419
Howard		**268**	**$61,701,228**	**595**
	Residential	222	$58,693,889	595
	Commercial	5	$2,402,623	
	Agriculture	41	$604,716	
Howell		**8537**	**$800,492,819**	**13229**
	Agriculture	2968	$6,261,676	
	Commercial	152	$64,842,147	
	Education	5	$4,880,111	
	Government	7	$2,581,300	
	Industrial	92	$36,339,613	
	Residential	5313	$685,587,973	13229
Iron		**2158**	**$585,632,866**	**3286**
	Residential	1369	$507,532,058	3286
	Industrial	27	$7,079,289	
	Government	18	$5,893,333	

	Commercial	96	$61,220,978	
	Agriculture	638	$1,231,208	
	Education	10	$2,676,000	
Jackson		**4759**	**$1,613,511,740**	**10425**
	Agriculture	214	$10,045,484	
	Commercial	144	$169,967,944	
	Education	17	$29,485,969	
	Government	1	$5,033,352	
	Industrial	21	$30,562,932	
	Residential	4362	$1,368,416,060	10425
Jasper		**5762**	**$1,009,141,458**	**11259**
	Agriculture	1083	$5,576,650	
	Commercial	186	$91,283,569	
	Education	9	$9,902,472	
	Government	24	$6,974,268	
	Industrial	79	$26,277,910	
	Residential	4381	$869,126,590	11259
Jefferson		**92286**	**$20,920,307,150**	**219994**
	Industrial	230	$357,468,918	
	Residential	83648	$18,832,628,811	219994
	Government	84	$66,659,103	
	Agriculture	4863	$44,760,090	
	Commercial	3332	$1,379,048,735	
	Education	129	$239,741,493	
Johnson		**3159**	**$816,672,706**	**5855**
	Agriculture	279	$918,421	
	Commercial	80	$50,137,894	
	Education	10	$47,670,483	
	Government	412	$13,452,844	
	Industrial	17	$29,890,286	
	Residential	2361	$674,602,779	5855
Knox		**30**	**$4,738,213**	**65**
	Agriculture	3	$9,002	
	Commercial	2	$359,355	
	Residential	25	$4,369,856	65
Laclede		**4465**	**$622,059,051**	**7552**
	Industrial	14	$10,367,460	
	Government	2	$1,187,769	
	Residential	3033	$565,045,832	7552
	Commercial	60	$39,631,333	
	Agriculture	1355	$4,173,520	
	Education	1	$1,653,136	
Lafayette		**814**	**$122,995,011**	**1080**

	Agriculture	345	$1,395,972	
	Commercial	21	$8,033,700	
	Government	2	$825,500	
	Industrial	5	$3,753,199	
	Residential	441	$108,986,641	1080
Lawrence		**999**	**$103,886,791**	**1300**
	Residential	512	$94,602,416	1300
	Government	2	$226,816	
	Commercial	25	$7,652,699	
	Agriculture	460	$1,404,860	
Lewis		**1131**	**$109,248,663**	**2044**
	Agriculture	239	$431,914	
	Commercial	32	$5,486,614	
	Government	3	$669,868	
	Industrial	16	$4,526,761	
	Residential	841	$98,133,506	2044
Lincoln		**8185**	**$1,372,680,649**	**14837**
	Industrial	9	$50,268,115	
	Government	1	$1,497,450	
	Residential	5134	$1,244,988,187	14837
	Commercial	40	$65,450,381	
	Education	2	$1,371,083	
	Agriculture	2999	$9,105,433	
Linn		**63**	**$7,198,874**	**87**
	Agriculture	26	$124,233	
	Residential	37	$7,074,641	87
Livingston		**64**	**$11,850,389**	**114**
	Agriculture	14	$48,061	
	Commercial	1	$999,539	
	Residential	49	$10,802,790	114
Macon		**645**	**$111,466,146**	**1142**
	Agriculture	144	$522,351	
	Commercial	41	$13,243,226	
	Education	8	$7,431,250	
	Government	3	$1,742,688	
	Industrial	1	$555,654	
	Residential	448	$87,970,978	1142
Madison		**3648**	**$716,274,437**	**7328**
	Residential	3079	$594,961,221	7328
	Industrial	63	$30,582,794	
	Government	24	$2,346,462	
	Commercial	238	$81,235,768	
	Agriculture	221	$909,810	

	Education	23	$6,238,383	
Maries		**2040**	**$248,747,397**	**3366**
	Agriculture	435	$1,281,656	
	Commercial	141	$26,085,404	
	Education	2	$4,670,800	
	Government	3	$1,707,600	
	Industrial	2	$2,316,933	
	Residential	1457	$212,685,003	3366
Marion		**580**	**$132,259,529**	**1109**
	Agriculture	70	$477,859	
	Commercial	28	$10,215,218	
	Education	6	$6,591,960	
	Government	2	$789,032	
	Residential	474	$114,185,460	1109
McDonald		**7880**	**$1,251,700,381**	**20208**
	Industrial	16	$45,948,952	
	Education	2	$12,154,500	
	Residential	7375	$1,168,940,711	20208
	Agriculture	445	$1,390,989	
	Commercial	42	$23,265,228	
Mercer		**120**	**$18,242,848**	**267**
	Agriculture	**23**	**$32,628**	
	Commercial	2	$549,775	
	Residential	95	$17,660,445	267
Miller		**6263**	**$983,471,406**	**12103**
	Agriculture	704	$2,522,457	
	Commercial	592	$80,295,204	
	Education	9	$8,325,000	
	Government	7	$1,773,395	
	Industrial	31	$30,118,931	
	Residential	4920	$860,436,419	12103
Mississippi		**6**	**$889,754**	**14**
	Residential	6	$889,754	14
Moniteau		**378**	**$52,132,546**	**567**
	Agriculture	168	$525,976	
	Residential	210	$51,606,569	567
Monroe		**568**	**$62,165,372**	**799**
	Government	1	$264,103	
	Residential	349	$56,552,399	799
	Agriculture	196	$505,577	
	Commercial	22	$4,843,293	
Montgomery		**3556**	**$285,079,817**	**4951**
	Agriculture	1199	$1,631,025	

	Commercial	71	$35,256,571	
	Government	2	$742,455	
	Industrial	54	$51,795,643	
	Residential	2230	$195,654,123	4951
Morgan		**11961**	**$1,869,928,848**	**24526**
	Residential	9361	$1,756,554,841	24526
	Industrial	57	$42,574,250	
	Government	2	$3,849,500	
	Education	17	$3,954,462	
	Agriculture	1261	$3,597,083	
	Commercial	1263	$59,398,713	
Newton		**13315**	**$2,331,171,642**	**27985**
	Agriculture	1755	$5,662,135	
	Commercial	567	$252,021,423	
	Education	38	$49,523,410	
	Government	21	$8,656,890	
	Industrial	45	$39,853,818	
	Residential	10889	$1,975,453,966	27985
Nodaway		**78**	**$14,162,251**	**128**
	Residential	56	$14,100,796	128
	Agriculture	22	$61,455	
Oregon		**2905**	**$232,486,881**	**4915**
	Agriculture	712	$787,194	
	Commercial	176	$38,486,338	
	Education	23	$4,448,426	
	Government	4	$1,791,400	
	Residential	1990	$186,973,522	4915
Osage		**2732**	**$556,474,836**	**4607**
	Agriculture	805	$1,967,207	
	Commercial	97	$32,837,271	
	Education	12	$26,233,655	
	Government	9	$4,662,750	
	Industrial	37	$40,741,070	
	Residential	1772	$450,032,882	4607
Ozark		**4031**	**$281,362,468**	**7144**
	Residential	3106	$234,217,231	7144
	Industrial	20	$8,250,746	
	Government	6	$3,508,091	
	Agriculture	2	$1,763	
	Commercial	199	$29,295,025	
	Agriculture	694	$611,612	
	Education	4	$5,478,000	
Pemiscot		**1202**	**$175,967,670**	**2746**

	Agriculture	13	$57,274	
	Commercial	57	$32,837,344	
	Education	2	$1,568,000	
	Government	8	$2,271,508	
	Industrial	1	$940,049	
	Residential	1121	$138,293,495	2746
Perry		**2163**	**$236,489,106**	**4240**
	Residential	1703	$202,330,894	4240
	Industrial	3	$5,361,712	
	Government	13	$5,719,316	
	Commercial	15	$20,525,217	
	Agriculture	429	$2,551,967	
Pettis		**945**	**$85,226,446**	**1404**
	Agriculture	396	$1,533,502	
	Commercial	3	$1,456,755	
	Government	1	$323,640	
	Industrial	1	$1,168,682	
	Residential	544	$80,743,867	1404
Phelps		**15124**	**$2,352,900,231**	**31296**
	Residential	13548	$1,971,238,450	31296
	Industrial	9	$33,930,462	
	Agriculture	1130	$6,027,725	
	Education	14	$21,795,030	
	Commercial	398	$303,007,493	
	Government	25	$16,901,071	
Pike		**1805**	**$381,920,135**	**3894**
	Residential	1583	$331,919,642	3894
	Industrial	12	$3,066,945	
	Commercial	117	$43,324,394	
	Education	1	$1,437,429	
	Agriculture	85	$446,905	
	Government	7	$1,724,819	
Platte		**2713**	**$988,956,392**	**6284**
	Agriculture	132	$1,281,741	
	Commercial	87	$63,256,950	
	Education	5	$7,234,366	
	Government	11	$7,168,721	
	Industrial	4	$3,010,546	
	Residential	2474	$907,004,068	6284
Polk		**2150**	**$278,090,438**	**3700**
	Residential	1434	$262,156,331	3700
	Industrial	4	$3,532,976	
	Commercial	17	$7,652,429	

	Education	2	$1,638,787	
	Agriculture	693	$3,109,915	
Pulaski		**13590**	**$4,633,958,499**	**29664**
	Agriculture	666	$4,292,183	
	Commercial	357	$297,723,401	
	Education	25	$54,169,643	
	Government	2065	$21,102,240	
	Industrial	32	$70,367,111	
	Residential	10445	$4,186,303,920	29664
Putnam		**279**	**$41,387,168**	**509**
	Agriculture	61	$159,260	
	Commercial	28	$4,188,561	
	Residential	190	$37,039,347	509
Ralls		**2115**	**$250,456,013**	**3175**
	Residential	1265	$236,079,800	3175
	Industrial	3	$1,853,147	
	Commercial	53	$9,572,300	
	Agriculture	791	$2,271,584	
	Government	3	$679,182	
Randolph		**2304**	**$371,658,331**	**5105**
	Agriculture	295	$999,192	
	Commercial	54	$26,850,063	
	Education	1	$1,329,053	
	Government	11	$3,965,662	
	Industrial	2	$1,304,832	
	Residential	1941	$337,209,530	5105
Ray		**572**	**$116,676,528**	**1099**
	Agriculture	137	$861,003	
	Commercial	4	$2,268,586	
	Residential	431	$113,546,938	1099
Reynolds		**3250**	**$266,919,223**	**7025**
	Industrial	53	$5,464,990	
	Government	2	$2,858,400	
	Residential	3002	$229,133,125	7025
	Commercial	99	$28,456,450	
	Agriculture	92	$344,519	
	Education	2	$661,739	
Ripley		**4904**	**$660,211,613**	**9593**
	Agriculture	1136	$1,757,487	
	Commercial	126	$63,188,442	
	Education	8	$20,345,600	
	Government	11	$6,037,167	
	Industrial	30	$38,403,818	

	Residential	3593	$530,479,098	9593
Saline		**497**	**$96,315,597**	**1190**
	Residential	456	$91,094,084	1190
	Commercial	9	$5,090,692	
	Agriculture	32	$130,821	
Schuyler		**330**	**$58,881,971**	**814**
	Agriculture	26	$73,281	
	Commercial	36	$7,089,351	
	Government	1	$580,133	
	Residential	267	$51,139,207	814
Scotland		**30**	**$4,798,013**	**63**
	Agriculture	7	$18,392	
	Residential	23	$4,779,621	63
Scott		**669**	**$105,056,599**	**1178**
	Government	3	$3,132,000	
	Residential	471	$96,689,910	1178
	Agriculture	193	$1,429,141	
	Commercial	2	$3,805,548	
Shannon		**3763**	**$284,244,363**	**8004**
	Commercial	306	$25,109,470	
	Education	24	$3,841,811	
	Government	24	$4,757,714	
	Industrial	82	$7,030,458	
	Residential	3032	$243,007,275	8004
	Agriculture	295	$497,635	
Shelby		**18**	**$2,311,902**	**24**
	Agriculture	8	$25,161	
	Residential	10	$2,286,741	24
St Charles		**18350**	**$5,827,890,062**	**44703**
	Agriculture	1062	$17,566,879	
	Commercial	329	$290,323,178	
	Education	7	$19,057,303	
	Government	10	$16,797,978	
	Industrial	9	$19,879,975	
	Residential	16933	$5,464,264,748	44703
St Clair		**3260**	**$260,420,514**	**5151**
	Industrial	8	$5,598,095	
	Residential	2352	$215,969,293	5151
	Government	3	$1,575,960	
	Agriculture	684	$1,333,005	
	Commercial	213	$35,944,160	
St Francois		**19052**	**$4,601,231,416**	**39963**
	Agriculture	847	$7,910,203	

	Commercial	1277	$535,366,037	
	Education	23	$36,065,736	
	Government	60	$16,569,615	
	Industrial	124	$130,804,970	
	Residential	16721	$3,874,514,855	39963
St Louis City		**65**	**$16,629,411**	**128**
	Residential	61	$13,128,913	128
	Industrial	4	$3,500,498	
St Louis Co		**52399**	**$14,608,448,627**	**117092**
	Agriculture	905	$175,174,577	
	Commercial	2631	$1,201,485,073	
	Education	77	$141,355,628	
	Government	89	$71,279,534	
	Industrial	111	$248,022,466	
	Residential	48586	$12,771,131,349	117092
Ste Genevieve		**4797**	**$788,877,900**	**8754**
	Residential	3544	$765,199,090	8754
	Agriculture	1230	$2,975,107	
	Commercial	13	$13,469,254	
	Industrial	10	$7,234,450	
Stoddard		**3664**	**$394,523,769**	**6687**
	Commercial	45	$37,498,510	
	Education	1	$1,702,381	
	Government	5	$5,902,895	
	Industrial	4	$3,467,303	
	Residential	2664	$341,670,360	6687
	Agriculture	945	$4,282,320	
Stone		**20306**	**$2,496,305,984**	**42663**
	Agriculture	2043	$3,481,423	
	Commercial	658	$60,733,553	
	Education	8	$7,201,818	
	Government	41	$5,587,038	
	Industrial	71	$33,913,795	
	Residential	17484	$2,385,251,930	42661
	Residential	1	$136,425	2
Sullivan		**143**	**$28,265,221**	**391**
	Residential	138	$25,962,203	391
	Commercial	2	$893,210	
	Agriculture	2	$4,665	
	Government	1	$1,405,143	
Taney		**19923**	**$4,854,059,961**	**38299**
	Residential	15958	$4,139,000,773	38299
	Agriculture	1659	$6,172,886	

	Commercial	2101	$601,902,496	
	Education	46	$28,545,729	
	Government	88	$19,243,915	
	Industrial	71	$59,194,162	
Texas		**14856**	**$908,026,559**	**28162**
	Agriculture	2940	$4,252,776	
	Commercial	447	$94,268,288	
	Education	43	$7,904,833	
	Government	19	$4,579,000	
	Industrial	97	$49,937,550	
	Residential	11310	$747,084,111	28162
Vernon		**731**	**$147,980,084**	**1171**
	Government	4	$1,357,120	
	Industrial	6	$16,236,176	
	Residential	482	$121,015,687	1171
	Education	1	$2,104,510	
	Agriculture	226	$552,932	
	Commercial	12	$6,713,659	
Warren		**16452**	**$2,681,440,279**	**37238**
	Agriculture	2477	$6,235,403	
	Commercial	128	$159,302,656	
	Education	14	$11,608,882	
	Government	22	$6,026,653	
	Industrial	19	$131,605,259	
	Residential	13792	$2,366,661,426	37238
Washington		**9825**	**$1,314,081,237**	**17170**
	Commercial	387	$90,356,784	
	Education	12	$6,809,633	
	Government	19	$5,570,378	
	Industrial	29	$10,787,642	
	Residential	6681	$1,198,874,104	17170
	Agriculture	2697	$1,682,696	
Wayne		**4566**	**$763,018,037**	**8546**
	Government	3	$5,332,500	
	Industrial	1	$2,126,640	
	Residential	3546	$690,631,454	8546
	Education	8	$5,003,789	
	Agriculture	932	$1,289,654	
	Commercial	76	$58,634,000	
Webster		**8790**	**$680,782,320**	**17942**
	Agriculture	2277	$4,316,159	
	Commercial	47	$19,773,734	
	Education	6	$6,213,231	

	Government	4	$521,762	
	Industrial	2	$1,726,841	
	Residential	6454	$648,230,592	17942
Worth		**2**	**$416,007**	**5**
	Residential	2	$416,007	5
Wright		**3217**	**$375,026,505**	**4763**
	Industrial	31	$8,849,880	
	Agriculture	1190	$2,950,220	
	Commercial	101	$43,297,845	
	Education	22	$10,443,714	
	Government	5	$3,905,556	
	Residential	1868	$305,579,291	4763

Table A.17 presents the estimated potential losses per county based upon the total acreage within the identified WUI area, the total structure value within the WUI area, the calculated average value per acre within the WUI area, and the average annual acreage burned for 2004-2021.

Table A.18. Wildfire Potential Loss Estimates

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Adair	14,601.51	$1,140,474,381	$78,107	106.43	$8,312,626
Andrew	8,703.93	$181,732,735	$20,879	279.34	$5,832,448
Atchison	490.83	$6,531,729	$13,308	142.11	$1,891,168
Audrain	2,157.85	$54,236,172	$25,134	32.14	$807,860
Barry	61,006.95	$843,497,700	$13,826	387.40	$5,356,230
Barton	2,302.44	$24,540,635	$10,659	345.38	$3,681,268
Bates	596.87	$8,511,476	$14,260	292.13	$4,165,756
Benton	56,326.29	$1,416,341,399	$25,145	1532.20	$38,527,557
Bollinger	28,799.97	$310,364,266	$10,777	209.10	$2,253,376
Boone	124,198.33	$4,665,103,926	$37,562	3.99	$149,955
Buchanan	19,061.54	$1,851,668,695	$97,142	184.18	$17,891,542
Butler	70,670.02	$1,442,664,694	$20,414	252.92	$5,163,168
Caldwell	510.72	$6,154,684	$12,051	308.62	$3,719,191
Callaway	78,311.78	$1,594,693,484	$20,363	306.30	$6,237,386
Camden	129,260.60	$6,850,197,593	$52,995	4296.09	$227,672,474
Cape Girardeau	30,737.90	$623,544,321	$20,286	173.23	$3,514,162
Carroll	675.86	$12,398,922	$18,345	857.09	$15,723,648
Carter	24,503.44	$268,259,519	$10,948	386.78	$4,234,366
Cass	4,539.45	$129,066,079	$28,432	138.80	$3,946,312
Cedar	20,476.54	$219,730,659	$10,731	436.82	$4,687,402
Chariton	619.17	$50,626,914	$81,766	305.70	$24,995,524
Christian	59,766.56	$1,125,063,053	$18,824	151.98	$2,860,842

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Clark	6,141.73	$64,932,118	$10,572	184.85	$1,954,281
Clay	7,079.11	$595,578,245	$84,132	74.56	$6,273,194
Clinton	1,558.58	$38,288,569	$24,566	380.79	$9,354,566
Cole	47,598.82	$2,042,673,022	$42,914	53.87	$2,311,606
Cooper	5,667.60	$166,824,609	$29,435	204.42	$6,017,109
Crawford	83,803.60	$1,519,195,711	$18,128	632.04	$11,457,652
Dade	6,043.34	$71,848,408	$11,889	410.99	$4,886,155
Dallas	29,063.73	$237,861,799	$8,184	2353.90	$19,264,665
Daviess	597.31	$10,960,841	$18,350	392.60	$7,204,364
Dekalb	670.25	$11,209,435	$16,724	613.24	$10,255,938
Dent	23,759.51	$207,897,063	$8,750	625.39	$5,472,193
Douglas	20,886.40	$131,929,403	$6,317	768.27	$4,852,815
Dunklin	1,990.07	$61,989,285	$31,149	2.09	$65,067
Franklin	227,202.99	$7,708,721,362	$33,929	190.45	$6,461,888
Gasconade	28,233.36	$759,278,320	$26,893	115.91	$3,117,147
Gentry	100.11	$931,713	$9,307	460.66	$4,287,329
Greene	82,526.68	$1,845,698,784	$22,365	318.13	$7,114,888
Grundy	1,951.87	$212,077,818	$108,654	125.95	$13,685,230
Harrison	546.75	$10,354,601	$18,938	586.51	$11,107,668
Henry	18,507.84	$781,447,031	$42,222	1556.18	$65,705,977
Hickory	32,310.73	$448,954,006	$13,895	299.65	$4,163,534
Holt	770.87	$20,737,687	$26,902	161.19	$4,336,220
Howard	5,279.88	$61,701,228	$11,686	127.99	$1,495,659
Howell	72,776.48	$800,492,819	$10,999	862.44	$9,486,260
Iron	27,603.24	$585,632,866	$21,216	431.17	$9,147,730
Jackson	27,949.59	$1,613,511,740	$57,729	35.37	$2,041,599
Jasper	34,020.87	$1,009,141,458	$29,662	209.70	$6,220,326
Jefferson	325,665.09	$20,920,307,150	$64,239	195.83	$12,579,796
Johnson	17,852.07	$816,672,706	$45,747	287.76	$13,164,137
Knox	182.33	$4,738,213	$25,987	48.38	$1,257,252
Laclede	58,622.15	$622,059,051	$10,611	1400.36	$14,859,660
Lafayette	6,070.04	$122,995,011	$20,263	104.76	$2,122,725
Lawrence	9,622.08	$103,886,791	$10,797	289.22	$3,122,606
Lewis	3,151.88	$109,248,663	$34,661	107.67	$3,732,112
Lincoln	70,149.18	$1,372,680,649	$19,568	133.11	$2,604,678
Linn	998	$7,198,874	$7,213	265.64	$1,916,157
Livingston	700.04	$11,850,389	$16,928	312.44	$5,289,016
Macon	4,131.03	$111,466,146	$26,983	262.10	$7,072,138
Madison	26,745.86	$716,274,437	$26,781	106.65	$2,856,064
Maries	18,145.40	$248,747,397	$13,709	251.27	$3,444,544
Marion	6,056.84	$132,259,529	$21,836	110.74	$2,418,223

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
McDonald	56,760.28	$1,251,700,381	$22,052	195.54	$4,312,114
Mercer	1,247.65	$18,242,848	$14,622	135.15	$1,976,059
Miller	58,644.02	$983,471,406	$16,770	468.78	$7,861,502
Mississippi	44.25	$889,754	$20,107	60.45	$1,215,527
Moniteau	6,156.81	$52,132,546	$8,467	215.27	$1,822,781
Monroe	5,076.19	$62,165,372	$12,246	250.99	$3,073,678
Montgomery	10,979.52	$285,079,817	$25,965	98.59	$2,559,960
Morgan	72,847.47	$1,869,928,848	$25,669	850.05	$21,819,945
New Madrid	0		#DIV/0!	10.23	#DIV/0!
Newton	92,687.81	$2,331,171,642	$25,151	511.18	$12,856,553
Nodaway	383.98	$14,162,251	$36,883	425.81	$15,705,017
Oregon	16,945.24	$232,486,881	$13,720	602.97	$8,272,669
Osage	31,326.79	$556,474,836	$17,764	87.73	$1,558,386
Ozark	27,504.09	$281,362,468	$10,230	793.20	$8,114,287
Pemiscot	705.98	$175,967,670	$249,253	30.67	$7,643,622
Perry	19,820.37	$236,489,106	$11,932	31.99	$381,746
Pettis	5,893.29	$85,226,446	$14,462	150.19	$2,172,005
Phelps	81,168.38	$2,352,900,231	$28,988	236.15	$6,845,442
Pike	14,387.28	$381,920,135	$26,546	176.03	$4,672,939
Platte	11,059.97	$988,956,392	$89,418	61.32	$5,483,040
Polk	29,550.67	$278,090,438	$9,411	330.77	$3,112,712
Pulaski	92,929.66	$4,633,958,499	$49,865	290.06	$14,463,741
Putnam	996.52	$41,387,168	$41,532	124.81	$5,183,687
Ralls	25,092.88	$250,456,013	$9,981	146.12	$1,458,403
Randolph	15,850.10	$371,658,331	$23,448	259.72	$6,089,908
Ray	7,826.53	$116,676,528	$14,908	438.36	$6,534,994
Reynolds	20,394.53	$266,919,223	$13,088	1594.76	$20,871,825
Ripley	62,591.62	$660,211,613	$10,548	385.42	$4,065,375
Saline	1,754.22	$96,315,597	$54,905	103.91	$5,705,431
Schuyler	769.96	$58,881,971	$76,474	85.16	$6,512,446
Scotland	463.4	$4,798,013	$10,354	191.26	$1,980,317
Scott	7,791.63	$105,056,599	$13,483	156.90	$2,115,509
Shannon	19,933.08	$284,244,363	$14,260	1118.43	$15,948,744
Shelby	297.22	$2,311,902	$7,778	123.87	$963,547
St Charles	67,573.20	$5,827,890,062	$86,246	54.71	$4,718,304
St Clair	26,356.15	$260,420,514	$9,881	1460.68	$14,432,768
St Francois	101,923.59	$4,601,231,416	$45,144	540.92	$24,419,054
Ste Genevieve	53,265.68	$788,877,900	$14,810	115.88	$1,716,203
St Louis	72,238.75	$14,608,448,627	$202,225	9.18	$1,856,646
St Louis City	111.85	$16,629,411	$148,676	0.11	$16,107
Stoddard	22,415.43	$394,523,769	$17,601	161.09	$2,835,330

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Stone	93,682.12	$2,496,305,984	$26,647	304.13	$8,103,988
Sullivan	831.1	$28,265,221	$34,009	393.98	$13,398,990
Taney	102,134.16	$4,854,059,961	$47,526	616.25	$29,287,931
Texas	55,882.72	$908,026,559	$16,249	650.56	$10,570,813
Vernon	6,257.11	$147,980,084	$23,650	563.94	$13,337,077
Warren	87,266.04	$2,681,440,279	$30,727	68.91	$2,117,547
Washington	103,621.44	$1,314,081,237	$12,682	1966.61	$24,939,614
Wayne	53,892.75	$763,018,037	$14,158	492.64	$6,974,791
Webster	68,601.58	$680,782,320	$9,924	338.32	$3,357,363
Worth	67.01	$416,007	$6,208	463.65	$2,878,424
Wright	24,606.21	$375,026,505	$15,241	344.00	$5,242,907

Drought– State Vulnerability Tables

Table A.19 provides the factors considered for drought and the ranges for the rating values assigned.

Table A.19. Ranges for Drought Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Social Vulnerability Index	1	2	3	4	5
Crop Exposure Ratio Rating	$379,000-$22,460,000	$23,369,000-$51,704,000	$53,142,000-$84,855,000	$84,855,000-$159,192,000	$181,201,000-$239,334,000
Annualized USDA Crop Claims Paid	$0	$1-$2,170,363	$2,170,364-$3,625,266	$3,625,267-$6,096,160	$6,096,161-$11,136,989
Likelihood of Occurrence of severe or extreme drought	0.15-0.35	0.38-0.50	0.54-0.69	0.73-1.00	1.23-1.31
Total Drought Vulnerability Rating	4-7	8-10	11-13	14-16	17-20

Table A.20 presents the factors considered for drought for each Missouri County.

Table A.20. Vulnerability of Missouri Counties to Drought

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2017 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Adair	3	$25,940,950	$2,594,095	3	$34,502,000	2	0.42	2	10	Medium Low
Andrew	2	$44,718,067	$4,471,807	4	$63,904,000	3	0.62	3	12	Medium
Atchison	4	$64,115,376	$6,411,538	5	$143,634,000	4	0.46	2	15	Medium High
Audrain	4	$111,369,887	$11,136,989	5	$151,778,000	4	0.35	1	14	Medium High
Barry	3	$14,805,606	$1,480,561	2	$16,817,000	1	0.81	4	10	Medium Low
Barton	3	$75,031,491	$7,503,149	5	$80,550,000	3	0.77	4	15	Medium High
Bates	3	$82,166,906	$8,216,691	5	$101,134,000	4	0.31	1	13	Medium
Benton	4	$13,816,195	$1,381,620	2	$16,114,000	1	0.50	2	9	Medium Low
Bollinger	2	$10,525,919	$1,052,592	2	$18,245,000	1	1.00	4	9	Medium Low
Boone	1	$24,402,785	$2,440,279	3	$46,361,000	2	0.31	1	7	Low
Buchanan	3	$30,255,075	$3,025,508	3	$59,750,000	3	0.50	2	11	Medium
Butler	4	$36,252,660	$3,625,266	3	$111,205,000	4	1.31	5	16	Medium High
Caldwell	3	$43,974,371	$4,397,437	4	$47,629,000	2	0.58	3	12	Medium
Callaway	2	$39,079,189	$3,907,919	4	$59,278,000	3	0.27	1	10	Medium Low
Camden	4	$322,806	$32,281	1	$1,710,000	1	0.35	1	7	Low
Cape Girardeau	3	$30,284,193	$3,028,419	3	$75,225,000	3	1.00	4	13	Medium
Carroll	3	$89,406,894	$8,940,689	5	$126,502,000	4	0.46	2	14	Medium High
Carter	4	$6,420	$642	1	$427,000	1	1.27	5	11	Medium
Cass	1	$31,463,805	$3,146,381	3	$98,757,000	4	0.50	2	10	Medium Low
Cedar	4	$5,213,849	$521,385	1	$6,639,000	1	0.54	3	9	Medium Low
Chariton	4	$83,897,254	$8,389,725	5	$98,313,000	4	0.42	2	15	Medium High
Christian	2	$1,432,358	$143,236	1	$5,181,000	1	0.77	4	8	Medium Low
Clark	2	$48,824,566	$4,882,457	4	$76,825,000	3	0.50	2	11	Medium
Clay	2	$15,175,842	$1,517,584	2	$19,329,000	1	0.54	3	8	Medium Low
Clinton	3	$55,024,629	$5,502,463	4	$64,506,000	3	0.54	3	13	Medium
Cole	2	$5,165,129	$516,513	1	$13,241,000	1	0.27	1	5	Low
Cooper	2	$51,943,550	$5,194,355	4	$62,480,000	3	0.54	3	12	Medium
Crawford	3	$404,205	$40,421	1	$3,727,000	1	0.35	1	6	Low
Dade	3	$10,603,780	$1,060,378	2	$29,596,000	2	0.54	3	10	Medium Low
Dallas	3	$1,390,979	$139,098	1	$4,893,000	1	0.54	3	8	Medium Low
Daviess	3	$63,501,955	$6,350,196	5	$48,068,000	2	0.62	3	13	Medium
DeKalb	1	$48,464,059	$4,846,406	4	$42,354,000	2	0.69	3	10	Medium Low
Dent	4	$83,508	$8,351	1	$2,577,000	1	0.35	1	7	Low

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2017 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Douglas	3	$238,637	$23,864	1	$1,488,000	1	0.46	2	7	Low
Dunklin	5	$48,990,108	$4,899,011	4	$193,535,000	5	0.69	3	17	High
Franklin	2	$12,522,681	$1,252,268	2	$26,135,000	2	0.35	1	7	Low
Gasconade	3	$6,948,072	$694,807	1	$14,957,000	1	0.23	1	6	Low
Gentry	4	$60,961,598	$6,096,160	4	$37,594,000	2	0.65	3	13	Medium
Greene	3	$4,091,473	$409,147	1	$8,215,000	1	0.73	4	9	Medium Low
Grundy	4	$44,935,052	$4,493,505	4	$49,205,000	2	0.62	3	13	Medium
Harrison	4	$72,225,682	$7,222,568	5	$68,651,000	3	0.65	3	15	Medium High
Henry	3	$33,412,058	$3,341,206	3	$59,164,000	3	0.31	1	10	Medium Low
Hickory	5	$2,890,783	$289,078	1	$5,616,000	1	0.46	2	9	Medium Low
Holt	3	$69,041,900	$6,904,190	5	$104,844,000	4	0.46	2	14	Medium High
Howard	2	$24,934,781	$2,493,478	3	$42,557,000	2	0.38	2	9	Medium Low
Howell	3	$452,329	$45,233	1	$4,461,000	1	0.35	1	6	Low
Iron	4	$0	$0	1	$379,000	1	0.23	1	7	Low
Jackson	3	$16,607,207	$1,660,721	2	$30,428,000	2	0.50	2	9	Medium Low
Jasper	3	$32,939,314	$3,293,931	3	$46,728,000	2	0.81	4	12	Medium
Jefferson	1	$1,174,350	$117,435	1	$7,502,000	1	0.38	2	5	Low
Johnson	1	$45,560,214	$4,556,021	4	$63,044,000	3	0.46	2	10	Medium Low
Knox	4	$89,164,780	$8,916,478	5	$51,704,000	2	0.23	1	12	Medium
Laclede	3	$4,296,779	$429,678	1	$5,293,000	1	0.31	1	6	Low
Lafayette	2	$44,607,332	$4,460,733	4	$131,558,000	4	0.54	3	13	Medium
Lawrence	3	$18,156,321	$1,815,632	2	$21,536,000	1	0.77	4	10	Medium Low
Lewis	3	$96,307,885	$9,630,789	5	$60,389,000	3	0.23	1	12	Medium
Lincoln	1	$40,245,677	$4,024,568	4	$60,029,000	3	0.46	2	10	Medium Low
Linn	4	$69,704,863	$6,970,486	5	$45,555,000	2	0.62	3	14	Medium High
Livingston	4	$70,727,015	$7,072,702	5	$75,761,000	3	0.62	3	15	Medium High
Macon	4	$66,102,377	$6,610,238	5	$69,979,000	3	0.46	2	14	Medium High
Madison	4	$184,771	$18,477	1	$794,000	1	0.23	1	7	Low
Maries	3	$1,669,551	$166,955	1	$4,731,000	1	0.31	1	6	Low
Marion	4	$54,718,577	$5,471,858	4	$75,999,000	3	0.23	1	12	Medium
McDonald	3	$2,411,828	$241,183	1	$4,501,000	1	0.88	4	9	Medium Low
Mercer	4	$34,297,913	$3,429,791	3	$23,369,000	2	0.54	3	12	Medium
Miller	4	$2,180,925	$218,093	1	$6,217,000	1	0.31	1	7	Low
Mississippi	4	$42,937,062	$4,293,706	4	No Data	1	1.23	5	14	Medium High
Moniteau	2	$14,454,632	$1,445,463	2	$30,832,000	2	0.27	1	7	Low
Monroe	3	$76,650,173	$7,665,017	5	$79,825,000	3	0.27	1	12	Medium

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2017 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Montgomery	4	$44,452,342	$4,445,234	4	$59,478,000	3	0.27	1	12	Medium
Morgan	4	$8,728,325	$872,833	2	$19,835,000	1	0.31	1	8	Medium Low
New Madrid	5	$65,383,248	$6,538,325	5	$231,399,000	5	1.23	5	20	High
Newton	2	$13,936,903	$1,393,690	2	$15,276,000	1	0.88	4	9	Medium Low
Nodaway	3	$66,146,594	$6,614,659	5	$127,824,000	4	0.69	3	15	Medium High
Oregon	4	$184,547	$18,455	1	$1,048,000	1	0.38	2	8	Medium Low
Osage	1	$7,523,747	$752,375	1	$17,385,000	1	0.27	1	4	Low
Ozark	3	$21,901	$2,190	1	$1,594,000	1	0.38	2	7	Low
Pemiscot	5	$49,473,063	$4,947,306	4	$159,192,000	4	0.69	3	16	Medium High
Perry	2	$21,703,627	$2,170,363	2	$35,789,000	2	0.81	4	10	Medium Low
Pettis	3	$57,694,593	$5,769,459	4	$84,855,000	3	0.35	1	11	Medium
Phelps	2	$143,535	$14,354	1	$2,477,000	1	0.31	1	5	Low
Pike	2	$75,067,944	$7,506,794	5	$79,142,000	3	0.27	1	11	Medium
Platte	1	$23,924,374	$2,392,437	3	$53,142,000	3	0.54	3	10	Medium Low
Polk	3	$3,347,988	$334,799	1	$11,019,000	1	0.50	2	7	Low
Pulaski	1	$1,011,361	$101,136	1	$1,286,000	1	0.31	1	4	Low
Putnam	3	$30,721,736	$3,072,174	3	$22,460,000	1	0.58	3	10	Medium Low
Ralls	2	$60,739,809	$6,073,981	4	$64,676,000	3	0.31	1	10	Medium Low
Randolph	2	$25,605,886	$2,560,589	3	$37,027,000	2	0.35	1	8	Medium Low
Ray	2	$39,283,415	$3,928,342	4	$63,912,000	3	0.50	2	11	Medium
Reynolds	4	$0	$0	1	No Data	1	0.23	1	7	Low
Ripley	4	$8,613,355	$861,336	2	$7,506,000	1	1.27	5	12	Medium
Saline	3	$66,648,163	$6,664,816	5	$181,201,000	5	0.35	1	14	Medium High
Schuyler	3	$19,884,264	$1,988,426	2	$14,901,000	1	0.46	2	8	Medium Low
Scotland	4	$45,292,138	$4,529,214	4	$57,552,000	3	0.50	2	13	Medium
Scott	3	$27,163,615	$2,716,362	3	$101,627,000	4	1.23	5	15	Medium High
Shannon	3	$19,520	$1,952	1	$900,000	1	0.38	2	7	Low
Shelby	3	$81,253,480	$8,125,348	5	$76,397,000	3	0.27	1	12	Medium
St. Charles	1	$39,621,971	$3,962,197	4	$53,817,000	3	0.35	1	9	Medium Low
St. Clair	4	$20,031,014	$2,003,101	2	$28,782,000	2	0.50	2	10	Medium Low
St. Francois	2	$1,178,178	$117,818	1	$7,815,000	1	0.23	1	5	Low
St. Louis City	5	$0	$0	1	No Data	1	0.15	1	8	Medium Low
St. Louis	2	$5,185,117	$518,512	1	$19,581,000	1	0.31	1	5	Low
Ste. Genevieve	2	$9,851,769	$985,177	2	$18,225,000	1	0.23	1	6	Low
Stoddard	3	$90,485,857	$9,048,586	5	$239,334,000	5	1.23	5	18	High
Stone	4	$383	$38	1	$1,508,000	1	0.85	4	10	Medium Low

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2017 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Sullivan	4	$35,867,493	$3,586,749	3	$28,441,000	2	0.65	3	12	Medium
Taney	5	$15,572	$1,557	1	$1,224,000	1	0.73	4	11	Medium
Texas	3	$274,032	$27,403	1	$5,189,000	1	0.35	1	6	Low
Vernon	4	$87,043,875	$8,704,388	5	$82,335,000	3	0.77	4	16	Medium High
Warren	2	$15,785,766	$1,578,577	2	$36,231,000	2	0.27	1	7	Low
Washington	3	$4,590	$459	1	$1,624,000	1	0.38	2	7	Low
Wayne	4	$1,812,021	$181,202	1	$7,814,000	1	1.31	5	11	Medium
Webster	2	$4,584,471	$458,447	1	$6,779,000	1	0.69	3	7	Low
Worth	4	$17,572,461	$1,757,246	2	$15,872,000	1	0.58	3	10	Medium Low
Wright	3	$1,889,038	$188,904	1	$3,135,000	1	0.27	1	6	Low

Extreme Heat/Extreme Cold – State Vulnerability Tables

Table A.21 provides the factors considered for extreme temperatures and the ranges for the rating values assigned.

Table A.21. Ranges for Extreme Temperature Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Common Factors					
Total Population	2,013-25,619	25,620-67,216	67,216-180,463	180,464-402,022	402,023-994,205
Percent Population Over 65	9.1 – 16.2%	16.3 – 18.9%	19 – 21.9%	22 – 26.2%	26.3 – 33.3%
Social Vulnerability	1	2	3	4	5
Extreme Heat					
Likelihood of Occurrence (# of events/ yrs. of data)	0.35-0.92	0.93-1.73	1.74-2.35	2.36-2.96	2.97-3.96
Extreme Cold					
Likelihood of Occurrence (# of events/ yrs. of data)	0.08-0.16	0.17-0.52	0.53-1.72	1.73-2.04	2.05-2.24

Table A.22 provides the calculated ranges applied to determine overall vulnerability of Missouri counties to extreme temperatures.

Table A.22. Ranges for Extreme Temperatures Vulnerability Rating

	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Extreme Heat Rating	5-6	7-8	9-10	11-12	13-15
Extreme Cold Rating	5-6	7-8	9	10-11	12-14

Table A.23 presents the factors considered for extreme temperatures for each Missouri County.

Table A.23. Population, Percent of Population over 65, and SOVI Data by County

County	Total Population Estimate (2019)	Total Population Rating	Percentage of Population over 65	Percent of Population over 65 Rating	SOVI Ranking	SOVI Rating
Adair	25,343	1	15.1	1	Medium	3
Andrew	17,712	1	19.4	3	Medium Low	2
Atchison	5,143	1	26.2	4	Medium High	4
Audrain	25,388	1	18.2	2	Medium High	4
Barry	35,789	2	21.0	3	Medium	3
Barton	11,754	1	21.2	3	Medium	3
Bates	16,172	1	19.6	3	Medium	3
Benton	19,443	1	31.2	5	Medium High	4
Bollinger	12,133	1	21.1	3	Medium Low	2
Boone	180,463	3	12.8	1	Low	1
Buchanan	87,364	3	16.7	2	Medium	3
Butler	42,478	2	19.2	3	Medium High	4
Caldwell	9,020	1	20.1	3	Medium	3
Callaway	44,743	2	16.7	2	Medium Low	2
Camden	46,305	2	28.9	5	Medium High	4
Cape Girardeau	78,871	3	17.1	2	Medium	3
Carroll	8,679	1	22.1	4	Medium	3
Carter	5,982	1	20.9	3	Medium High	4
Cass	105,780	3	17.3	2	Low	1
Cedar	14,349	1	23.7	4	Medium High	4
Chariton	7,426	1	24.3	4	Medium High	4
Christian	88,595	3	16.1	1	Medium Low	2
Clark	6,797	1	21.5	3	Medium Low	2
Clay	249,948	4	14.4	1	Medium Low	2
Clinton	20,387	1	18.2	2	Medium	3
Cole	76,745	3	17.3	2	Medium Low	2
Cooper	17,709	1	18.3	2	Medium Low	2
Crawford	23,920	1	20.1	3	Medium	3
Dade	7,561	1	23.9	4	Medium	3
Dallas	16,878	1	20.8	3	Medium	3
Daviess	8,278	1	21.2	3	Medium	3
DeKalb	12,547	1	16.6	2	Low	1
Dent	15,573	1	22.3	4	Medium High	4
Douglas	13,185	1	24.9	4	Medium	3
Dunklin	29,131	2	18.8	2	High	5
Franklin	103,967	3	18.0	2	Medium Low	2
Gasconade	14,706	1	23.1	4	Medium	3
Gentry	6,571	1	19.9	3	Medium High	4
Greene	293,086	4	16.8	2	Medium	3
Grundy	9,850	1	22.4	4	Medium High	4
Harrison	8,352	1	22.8	4	Medium High	4
Henry	21,824	1	22.1	4	Medium	3

County	Total Population Estimate (2019)	Total Population Rating	Percentage of Population over 65	Percent of Population over 65 Rating	SOVI Ranking	SOVI Rating
Hickory	9,544	1	33.3	5	High	5
Holt	4,403	1	26.2	4	Medium	3
Howard	10,001	1	19.7	3	Medium Low	2
Howell	40,117	2	20.1	3	Medium	3
Iron	10,125	1	21.9	3	Medium High	4
Jackson	703,011	5	15.4	1	Medium	3
Jasper	121,328	3	16.0	1	Medium	3
Jefferson	225,081	4	15.5	1	Low	1
Johnson	54,062	2	12.9	1	Low	1
Knox	3,959	1	22.2	4	Medium High	4
Laclede	35,723	2	17.8	2	Medium	3
Lafayette	32,708	2	18.9	2	Medium Low	2
Lawrence	38,355	2	18.4	2	Medium	3
Lewis	9,776	1	18.8	2	Medium	3
Lincoln	59,013	2	13.7	1	Low	1
Linn	11,920	1	21.4	3	Medium High	4
Livingston	15,227	1	19.5	3	Medium High	4
Macon	15,117	1	23.6	4	Medium High	4
Madison	12,088	1	28.5	3	Medium High	4
Maries	8,697	1	27.3	4	Medium	3
Marion	28,530	2	6.7	2	Medium High	4
McDonald	22,837	1	22.9	1	Medium	3
Mercer	3,617	1	22.5	4	Medium High	4
Miller	25,619	1	19.6	3	Medium High	4
Mississippi	13,180	1	18.2	2	Medium High	4
Moniteau	16,132	1	16.2	1	Medium Low	2
Monroe	8,644	1	24.0	4	Medium	3
Montgomery	11,551	1	21.3	3	Medium High	4
Morgan	20,627	1	23.4	1	Medium High	4
New Madrid	17,076	1	19.5	3	High	5
Newton	58,236	2	18.4	2	Medium Low	2
Nodaway	22,092	1	15.6	1	Medium	3
Oregon	10,529	1	23.7	4	Medium High	4
Osage	13,615	1	17.7	2	Low	1
Ozark	9,174	1	29.3	5	Medium	3
Pemiscot	15,805	1	17.6	2	High	5
Perry	19,136	1	19.2	3	Medium Low	2
Pettis	42,339	2	17.1	2	Medium	3
Phelps	44,573	2	17.0	2	Medium Low	2
Pike	18,302	1	17.8	2	Medium Low	2
Platte	104,418	3	15.0	1	Low	1
Polk	32,149	1	18.3	2	Medium	3
Pulaski	52,607	2	9.1	1	Low	1
Putnam	4,696	1	24.9	4	Medium	3
Ralls	10,309	1	22.2	4	Medium Low	2
Randolph	24,748	1	17.2	2	Medium Low	2

County	Total Population Estimate (2019)	Total Population Rating	Percentage of Population over 65	Percent of Population over 65 Rating	SOVI Ranking	SOVI Rating
Ray	23,018	1	18.9	2	Medium Low	2
Reynolds	6,270	1	23.7	4	Medium High	4
Ripley	13,288	1	20.8	3	Medium High	4
Saline	22,761	1	18.7	2	Medium	3
Schuyler	4,660	1	19.5	3	Medium	3
Scotland	4,902	1	18.5	2	Medium High	4
Scott	38,280	2	18.6	2	Medium	3
Shannon	8,166	1	22.6	4	Medium	3
Shelby	5,930	1	21.8	3	Medium	3
St. Charles	402,022	4	15.8	1	Low	1
St. Clair	9,397	1	27.6	5	Medium High	4
St. Francois	67,215	2	16.6	2	Medium Low	2
St. Louis City	300,576	4	14.3	1	High	5
St. Louis	994,205	5	18.5	2	Medium Low	2
Ste. Genevieve	17,894	1	20.1	3	Medium Low	2
Stoddard	29,025	2	20.3	3	Medium	3
Stone	31,952	1	31.6	5	Medium High	4
Sullivan	6,089	1	20.8	3	Medium High	4
Taney	55,928	2	22.1	4	High	5
Texas	25,398	1	21.5	3	Medium	3
Vernon	20,563	1	19.7	3	Medium High	4
Warren	35,649	2	17.8	2	Medium Low	2
Washington	24,730	1	17.2	2	Medium	3
Wayne	12,873	1	24.3	4	Medium High	4
Webster	39,592	2	15.7	1	Medium Low	2
Worth	2,013	1	25.9	4	Medium High	4
Wright	18,289	1	19.6	3	Medium	3

Table A.24 provides additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis and the total overall vulnerability rating for extreme temperatures.

Table A.24. Likelihood of Occurrence and Overall Vulnerability Rating for Extreme Temperatures

County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Adair	16	0.62	1	6	Low	7	0.28	2	7	Low Medium
Andrew	16	0.62	1	7	Low Medium	6	0.24	2	8	Low Medium
Atchison	16	0.62	1	10	Medium	5	0.2	2	11	Medium High
Audrain	48	1.85	3	10	Medium	2	0.08	1	8	Low Medium
Barry	11	0.42	1	9	Medium	6	0.24	2	10	Medium High
Barton	11	0.42	1	8	Low Medium	6	0.24	2	9	Medium
Bates	18	0.69	1	8	Low Medium	6	0.24	2	9	Medium
Benton	11	0.42	1	11	Medium High	6	0.24	2	12	High
Bollinger	66	2.54	4	10	Medium	56	2.24	5	11	Medium High
Boone	56	2.15	3	8	Low Medium	2	0.08	1	6	Low
Buchanan	17	0.65	1	9	Medium	6	0.24	2	10	Medium High
Butler	77	2.96	4	13	High	48	1.92	4	13	High
Caldwell	17	0.65	1	8	Low Medium	6	0.24	2	9	Medium
Callaway	56	2.15	3	9	Medium	4	0.16	1	7	Low Medium
Camden	11	0.42	1	12	Medium High	6	0.24	2	13	High
Cape Girardeau	69	2.65	4	12	Medium High	54	2.16	5	13	High
Carroll	17	0.65	1	9	Medium	6	0.24	2	10	Medium High
Carter	68	2.62	4	12	Medium High	54	2.16	5	13	High
Cass	19	0.73	1	7	Low Medium	6	0.24	2	8	Low Medium
Cedar	11	0.42	1	10	Medium	6	0.24	2	11	Medium High
Chariton	17	0.65	1	10	Medium	6	0.24	2	11	Medium High
Christian	11	0.42	1	7	Low Medium	6	0.24	2	8	Low Medium
Clark	11	0.42	1	7	Low Medium	13	0.52	2	8	Low Medium
Clay	23	0.88	1	8	Low Medium	6	0.24	2	9	Medium
Clinton	17	0.65	1	7	Low Medium	6	0.24	2	8	Low Medium
Cole	51	1.96	3	10	Medium	2	0.08	1	8	Low Medium
Cooper	16	0.62	1	6	Low	6	0.24	2	7	Low Medium
Crawford	54	2.08	3	10	Medium	2	0.08	1	8	Low Medium
Dade	11	0.42	1	9	Medium	5	0.2	2	10	Medium High
Dallas	11	0.42	1	8	Low Medium	6	0.24	2	9	Medium
Daviess	15	0.58	1	8	Low Medium	6	0.24	2	9	Medium
DeKalb	16	0.62	1	5	Low	6	0.24	2	6	Low

County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Dent	11	0.42	1	10	Medium	5	0.2	2	11	Medium High
Douglas	11	0.42	1	9	Medium	5	0.2	2	10	Medium High
Dunklin	45	1.73	2	11	Medium High	3	0.12	1	10	Medium High
Franklin	58	2.23	3	10	Medium	2	0.08	1	8	Low Medium
Gasconade	53	2.04	3	11	Medium High	2	0.08	1	9	Medium
Gentry	17	0.65	1	9	Medium	7	0.28	2	10	Medium High
Greene	15	0.58	1	10	Medium	6	0.24	2	11	Medium High
Grundy	15	0.58	1	10	Medium	6	0.24	2	11	Medium High
Harrison	17	0.65	1	10	Medium	7	0.28	2	11	Medium High
Henry	17	0.65	1	9	Medium	6	0.24	2	10	Medium High
Hickory	11	0.42	1	12	Medium High	4	0.16	1	12	High
Holt	16	0.62	1	9	Medium	6	0.24	2	10	Medium High
Howard	16	0.62	1	7	Low Medium	6	0.24	2	8	Low Medium
Howell	12	0.46	1	9	Medium	5	0.2	2	10	Medium High
Iron	50	1.92	3	11	Medium High	2	0.08	1	9	Medium
Jackson	33	1.27	2	11	Medium High	8	0.32	2	11	Medium High
Jasper	13	0.50	1	8	Low Medium	6	0.24	2	9	Medium
Jefferson	61	2.35	3	9	Medium	2	0.08	1	7	Low Medium
Johnson	17	0.65	1	5	Low	6	0.24	2	6	Low
Knox	39	1.50	2	11	Medium High	2	0.08	1	10	Medium High
Laclede	11	0.42	1	8	Low Medium	7	0.28	2	9	Medium
Lafayette	17	0.65	1	7	Low Medium	6	0.24	2	8	Low Medium
Lawrence	12	0.46	1	8	Low Medium	6	0.24	2	9	Medium
Lewis	40	1.54	2	8	Low Medium	2	0.08	1	7	Low Medium
Lincoln	53	2.04	3	7	Low Medium	2	0.08	1	5	Low
Linn	16	0.62	1	9	Medium	7	0.28	2	10	Medium High
Livingston	15	0.58	1	9	Medium	6	0.24	2	10	Medium High
Macon	16	0.62	1	10	Medium	7	0.28	2	11	Medium High
Madison	49	1.88	3	11	Medium High	2	0.08	1	9	Medium
Maries	11	0.42	1	9	Medium	5	0.2	2	10	Medium High
Marion	42	1.62	2	10	Medium	2	0.08	1	9	Medium
McDonald	11	0.42	1	6	Low	5	0.2	2	7	Low Medium
Mercer	16	0.62	1	10	Medium	7	0.28	2	11	Medium High
Miller	11	0.42	1	9	Medium	5	0.2	2	10	Medium High
Mississippi	71	2.73	4	11	Medium High	43	1.72	3	10	Medium High
Moniteau	51	1.96	3	7	Low Medium	2	0.08	1	5	Low
Monroe	42	1.62	2	10	Medium	2	0.08	1	9	Medium

County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Montgomery	54	2.08	3	11	Medium High	2	0.08	1	9	Medium
Morgan	11	0.42	1	7	Low Medium	6	0.24	2	8	Low Medium
New Madrid	76	2.92	4	13	High	43	1.72	3	12	High
Newton	11	0.42	1	7	Low Medium	6	0.24	2	8	Low Medium
Nodaway	17	0.65	1	6	Low	7	0.28	2	7	Low Medium
Oregon	11	0.42	1	10	Medium	3	0.12	1	10	Medium High
Osage	51	1.96	3	7	Low Medium	2	0.08	1	5	Low
Ozark	11	0.42	1	10	Medium	5	0.2	2	11	Medium High
Pemiscot	44	1.69	2	10	Medium	3	0.12	1	9	Medium
Perry	64	2.46	4	10	Medium	56	2.24	5	11	Medium High
Pettis	17	0.65	1	8	Low Medium	6	0.24	2	9	Medium
Phelps	11	0.42	1	7	Low Medium	5	0.2	2	8	Low Medium
Pike	42	1.62	2	7	Low Medium	2	0.08	1	6	Low
Platte	24	0.92	1	6	Low	6	0.24	2	7	Low Medium
Polk	11	0.42	1	7	Low Medium	5	0.2	2	8	Low Medium
Pulaski	11	0.42	1	5	Low	5	0.2	2	6	Low
Putnam	16	0.62	1	9	Medium	7	0.28	2	10	Medium High
Ralls	41	1.58	2	9	Medium	2	0.08	1	8	Low Medium
Randolph	16	0.62	1	6	Low	6	0.24	2	7	Low Medium
Ray	16	0.62	1	6	Low	6	0.24	2	7	Low Medium
Reynolds	48	1.85	3	12	Medium High	2	0.08	1	10	Medium High
Ripley	74	2.85	4	12	Medium High	51	2.04	4	12	High
Saline	16	0.62	1	7	Low Medium	6	0.24	2	8	Low Medium
Schuyler	16	0.62	1	8	Low Medium	7	0.28	2	9	Medium
Scotland	9	0.35	1	8	Low Medium	11	0.44	2	9	Medium
Scott	72	2.77	4	11	Medium High	50	2	4	11	Medium High
Shannon	11	0.42	1	9	Medium	5	0.2	2	10	Medium High
Shelby	40	1.54	2	9	Medium	2	0.08	1	8	Low Medium
St. Charles	75	2.88	4	10	Medium	2	0.08	1	7	Low Medium
St. Clair	11	0.42	1	11	Medium High	6	0.24	2	12	High
St. Francois	55	2.12	3	9	Medium	2	0.08	1	7	Low Medium
St. Louis City	103	3.96	5	15	High	2	0.08	1	11	Medium High
St. Louis	93	3.58	5	14	High	3	0.12	1	10	Medium High
Ste. Genevieve	52	2.00	3	9	Medium	2	0.08	1	7	Low Medium
Stoddard	75	2.88	4	12	Medium High	47	1.88	4	12	High
Stone	11	0.42	1	11	Medium High	5	0.2	2	12	High
Sullivan	16	0.62	1	9	Medium	7	0.28	2	10	Medium High

County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Taney	11	0.42	1	12	Medium High	5	0.2	2	13	High
Texas	11	0.42	1	8	Low Medium	5	0.2	2	9	Medium
Vernon	12	0.46	1	9	Medium	6	0.24	2	10	Medium High
Warren	52	2.00	3	9	Medium	2	0.08	1	7	Low Medium
Washington	51	1.96	3	9	Medium	2	0.08	1	7	Low Medium
Wayne	68	2.62	4	13	High	55	2.2	5	14	High
Webster	11	0.42	1	6	Low	6	0.24	2	7	Low Medium
Worth	16	0.62	1	10	Medium	7	0.28	2	11	Medium High
Wright	11	0.42	1	8	Low Medium	5	0.2	2	9	Medium

Severe Thunderstorms – State Vulnerability Tables

Table A.25 provides the factors considered for severe thunderstorms and the ranges for the rating values assigned.

Table A.25. Ranges for Severe Thunderstorm Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium Low (2)	Medium (3)	Medium High (4)	High (5)
Common Factors					
Housing Density (# per sq. mile)	4-46	47-140	141-283	284-871	872-2,865
Building Exposure ($1,000)	$286,351-$3,053,773	$3,381,480-$9,044,465	$11,043,270-$24,814,360	$30,225,497-$50,440,776	$96,532,305-$153,542,314
Percent Mobile Homes	0.23-4.38	4.39-8.24	8.25-13	13.01-23.77	23.78-34.58
Social Vulnerability	1	2	3	4	5
Wind					
Likelihood of Occurrence (# of events/ yrs. of data)	0.88-3.27	3.28-5.31	5.32-8.77	8.78-15.23	15.24-23.5
Average Annual Property Loss (annual property loss/ yrs of data)	$0	$1-$144,538	$144,539-$315,712	$315,713-$724,312	$724,313-$2,006,385
Hail					
Likelihood of Occurrence (# of events/ yrs. of data)	1.12-3.12	3.13-4.92	4.93-7.23	7.24-11.42	11.43-17.23
Average Annual Property Loss (annual property loss/ yrs. of data)	$0	$1-$138,907	$139,908-$377,884	$377,885-$7,846,346	$7,846,347-$32,787,692
Lightning					
Likelihood of Occurrence (# of events/ yrs. of data)	0	0.01-0.12	0.13-0.23	0.24-0.35	0.36-0.65
Average Annual Property Loss (annual property loss/ yrs. Of data)	$0	$1-$6,038	$6,039-$15,192	$15,193-$30,846	$30,847-$48,000

Once the ranges were determined and applied to all factors considered in the analysis for wind, hail, and lightning, they were rated individually and factored together to determine an overall vulnerability rating for thunderstorms. **Table A.26** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to severe thunderstorms.

Table A.26. Ranges for Severe Thunderstorm Combined Vulnerability Rating

	Low (1)	Medium Low (2)	Medium (3)	Medium High (4)	High (5)
Severe Thunderstorm Combined Vulnerability	11-16	17-19	20-23	24-29	30-36

Table A.27 presents the factors considered for severe thunderstorms for each Missouri County.

Table A.27. Housing Density, Building Exposure, SOVI, and Mobile Home Data by County

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Adair	$2,684,103,000	1	20.53	1	Medium	3	5.7	2
Andrew	$1,833,402,000	1	16.91	1	Medium Low	2	6.7	2
Atchison	$845,407,000	1	5.39	1	Medium High	4	2.2	1
Audrain	$2,802,758,000	1	15.79	1	Medium High	4	4.9	2
Barry	$3,698,931,000	2	22.69	1	Medium	3	18.3	4
Barton	$1,497,507,000	1	9.44	1	Medium	3	10.2	3
Bates	$1,776,058,000	1	9.37	1	Medium	3	11.7	3
Benton	$2,500,952,000	1	20.27	1	Medium High	4	17.8	5
Bollinger	$1,065,618,000	1	9.51	1	Medium Low	2	12.4	4
Boone	$19,011,341,000	3	115.78	2	Low	1	4.1	1
Buchanan	$11,043,270,000	3	95.14	2	Medium	3	4.2	1
Butler	$4,240,466,000	2	28.60	1	Medium High	4	13.0	3
Caldwell	$1,038,687,000	1	11.10	1	Medium	3	10.3	4
Callaway	$4,541,285,000	2	22.83	1	Medium Low	2	13.7	4
Camden	$8,555,313,000	2	64.15	2	Medium High	4	11.1	2
Cape Girardeau	$9,044,465,000	2	60.45	2	Medium	3	6.5	2
Carroll	$1,255,053,000	1	6.69	1	Medium	3	7.1	3
Carter	$529,336,000	1	6.44	1	Medium High	4	17.9	5
Cass	$12,120,597,000	3	61.53	2	Low	1	4.3	2
Cedar	$1,338,216,000	1	15.31	1	Medium High	4	15.6	4
Chariton	$961,579,000	1	5.52	1	Medium High	4	10.1	3
Christian	$7,643,064,000	2	62.76	2	Medium Low	2	4.9	2
Clark	$749,824,000	1	6.95	1	Medium Low	2	15.7	4
Clay	$30,225,497,000	4	250.91	3	Medium Low	2	1.8	1
Clinton	$2,458,398,000	1	21.69	1	Medium	3	4.3	2
Cole	$11,244,484,000	3	85.39	2	Medium Low	2	2.0	1
Cooper	$1,844,606,000	1	13.27	1	Medium Low	2	5.9	2
Crawford	$2,565,695,000	1	16.30	1	Medium	3	15.1	4
Dade	$749,772,000	1	8.07	1	Medium	3	15.3	3
Dallas	$1,367,145,000	1	14.21	1	Medium	3	19.7	4
Daviess	$1,005,674,000	1	7.43	1	Medium	3	9.6	3
DeKalb	$1,137,449,000	1	10.34	1	Low	1	9.2	4
Dent	$1,537,144,000	1	9.74	1	Medium High	4	18.0	4
Douglas	$1,057,018,000	1	8.01	1	Medium	3	13.9	4

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Dunklin	$3,039,549,000	1	26.71	1	High	5	9.6	3
Franklin	$12,583,890,000	3	49.73	2	Medium Low	2	8.7	3
Gasconade	$2,038,105,000	1	15.78	1	Medium	3	7.9	3
Gentry	$734,656,000	1	6.53	1	Medium High	4	4.0	3
Greene	$32,216,001,000	4	200.86	3	Medium	3	3.4	1
Grundy	$1,234,611,000	1	11.49	1	Medium High	4	5.5	2
Harrison	$1,087,927,000	1	6.06	1	Medium High	4	6.5	3
Henry	$2,668,413,000	1	15.76	1	Medium	3	11.4	3
Hickory	$879,093,000	1	17.25	1	High	5	34.6	5
Holt	$662,533,000	1	6.03	1	Medium	3	9.8	2
Howard	$1,106,490,000	1	9.90	1	Medium Low	2	11.1	4
Howell	$3,615,730,000	2	19.78	1	Medium	3	15.2	4
Iron	$1,043,899,000	1	9.64	1	Medium High	4	16.6	4
Jackson	$96,532,305,000	5	543.08	4	Medium	3	1.0	1
Jasper	$12,158,441,000	3	81.85	2	Medium	3	6.4	2
Jefferson	$24,814,360,000	3	140.32	2	Low	1	9.9	3
Johnson	$6,312,436,000	2	27.01	1	Low	1	8.2	3
Knox	$461,629,000	1	4.52	1	Medium High	4	8.7	3
Laclede	$3,381,480,000	2	21.04	1	Medium	3	16.5	4
Lafayette	$4,199,028,000	2	23.66	1	Medium Low	2	7.0	3
Lawrence	$3,511,788,000	2	27.33	1	Medium	3	10.2	3
Lewis	$1,054,161,000	1	9.00	1	Medium	3	13.9	4
Lincoln	$5,005,508,000	2	35.07	1	Low	1	14.9	4
Linn	$1,622,177,000	1	10.37	1	Medium High	4	6.1	3
Livingston	$1,789,759,000	1	12.90	1	Medium High	4	6.7	2
Macon	$1,687,915,000	1	9.59	1	Medium High	4	21.5	3
Madison	$1,216,520,000	1	12.11	1	Medium High	4	11.1	3
Maries	$995,884,000	1	8.75	1	Medium	3	9.7	4
Marion	$3,384,001,000	2	30.00	1	Medium High	4	13.9	2
McDonald	$1,699,965,000	1	18.53	1	Medium	3	4.4	5
Mercer	$426,966,000	1	4.68	1	Medium High	4	3.9	3
Miller	$2,529,668,000	1	21.89	1	Medium High	4	13.7	3
Mississippi	$1,144,050,000	1	13.93	1	Medium High	4	7.0	2
Moniteau	$1,556,217,000	1	14.88	1	Medium Low	2	6.7	2
Monroe	$1,002,707,000	1	7.49	1	Medium	3	16.0	4
Montgomery	$1,486,338,000	1	11.71	1	Medium High	4	12.5	3

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Morgan	$2,974,448,000	1	26.11	1	Medium High	4	17.8	4
New Madrid	$1,798,374,000	1	12.76	1	High	5	13.8	3
Newton	$5,552,640,000	2	39.79	1	Medium Low	2	13.8	4
Nodaway	$2,548,598,000	1	11.19	1	Medium	3	6.8	2
Oregon	$912,583,000	1	6.93	1	Medium High	4	16.9	4
Osage	$1,653,491,000	1	11.06	1	Low	1	6.4	2
Ozark	$929,161,000	1	7.66	1	Medium	3	19.3	4
Pemiscot	$1,677,658,000	1	16.58	1	High	5	7.3	3
Perry	$2,265,290,000	1	18.70	1	Medium Low	2	7.1	2
Pettis	$4,555,540,000	2	26.72	1	Medium	3	5.1	2
Phelps	$4,986,304,000	2	30.62	1	Medium Low	2	9.2	3
Pike	$1,977,682,000	1	11.83	1	Medium Low	2	10.6	3
Platte	$12,439,139,000	3	101.95	2	Low	1	0.4	1
Polk	$2,714,054,000	1	21.44	1	Medium	3	11.6	3
Pulaski	$5,518,913,000	2	35.06	1	Low	1	9.1	3
Putnam	$554,649,000	1	5.75	1	Medium	3	8.7	2
Ralls	$1,228,558,000	1	11.06	1	Medium Low	2	8.7	4
Randolph	$2,487,755,000	1	22.43	1	Medium Low	2	12.0	3
Ray	$2,767,612,000	1	17.84	1	Medium Low	2	4.3	2
Reynolds	$718,939,000	1	4.98	1	Medium High	4	16.1	4
Ripley	$1,146,993,000	1	10.55	1	Medium High	4	22.3	5
Saline	$2,472,916,000	1	13.47	1	Medium	3	7.1	2
Schuyler	$414,534,000	1	6.83	1	Medium	3	12.7	3
Scotland	$562,547,000	1	5.43	1	Medium High	4	9.4	2
Scott	$4,139,364,000	2	41.29	1	Medium	3	11.2	3
Shannon	$728,024,000	1	4.16	1	Medium	3	18.1	4
Shelby	$834,550,000	1	6.39	1	Medium	3	11.1	3
St. Charles	$44,937,555,000	4	282.62	3	Low	1	2.7	1
St. Clair	$1,021,125,000	1	8.43	1	Medium High	4	20.4	5
St. Francois	$6,688,219,000	2	67.37	2	Medium Low	2	10.4	4
St. Louis City	$50,440,776,000	4	2865.50	5	High	5	0.4	1
St. Louis	$153,542,314,000	5	871.01	4	Medium Low	2	0.2	1
Ste. Genevieve	$2,288,166,000	1	17.55	1	Medium Low	2	9.5	3
Stoddard	$3,053,773,000	1	16.70	1	Medium	3	9.2	3
Stone	$3,900,275,000	2	46.11	1	Medium High	4	13.7	4
Sullivan	$648,402,000	1	5.15	1	Medium High	4	10.4	3

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Taney	$6,216,495,000	2	49.36	2	High	5	14.8	3
Texas	$2,384,744,000	1	9.97	1	Medium	3	16.0	4
Vernon	$2,402,354,000	1	11.61	1	Medium High	4	10.6	3
Warren	$3,695,873,000	2	37.43	1	Medium Low	2	14.7	3
Washington	$1,919,481,000	1	14.58	1	Medium	3	33.1	5
Wayne	$1,271,311,000	1	10.69	1	Medium High	4	23.8	5
Webster	$2,768,483,000	1	25.12	1	Medium Low	2	10.6	3
Worth	$286,351,000	1	4.76	1	Medium High	4	6.1	2
Wright	$1,618,341,000	1	12.74	1	Medium	3	15.3	4

Table A.28 provides the additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis.

Table A.28. High Wind, Hail, and Lightning Events, Likelihood of Occurrence, and Associated Ratings

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Adair	76	2.92	1	76	2.92	1	1	0.04	1
Andrew	64	2.46	1	88	3.38	2	0	0.00	1
Atchison	100	3.85	2	124	4.77	2		0.00	1
Audrain	98	3.77	2	64	2.46	1	3	0.12	2
Barry	207	7.96	3	248	9.54	4	2	0.08	1
Barton	134	5.15	2	159	6.12	3	1	0.04	1
Bates	68	2.62	1	143	5.50	3	1	0.04	1
Benton	130	5.00	2	126	4.85	2	2	0.08	1
Bollinger	79	3.04	1	78	3.00	1	1	0.04	1
Boone	163	6.27	3	250	9.62	4	15	0.58	5
Buchanan	114	4.38	2	120	4.62	2	0	0.00	1
Butler	133	5.12	2	101	3.88	2	1	0.04	1
Caldwell	59	2.27	1	75	2.88	1	0	0.00	1
Callaway	126	4.85	2	140	5.38	3	7	0.27	4
Camden	155	5.96	3	178	6.85	3	0	0.00	1
Cape Girardeau	147	5.65	3	97	3.73	2	9	0.35	4
Carroll	47	1.81	1	83	3.19	2	0	0.00	1
Carter	64	2.46	1	67	2.58	1	2	0.08	1
Cass	169	6.50	3	275	10.58	4	1	0.04	1
Cedar	106	4.08	2	112	4.31	2	1	0.04	1
Chariton	53	2.04	1	71	2.73	1	0	0.00	1
Christian	261	10.04	4	207	7.96	4	8	0.31	4
Clark	98	3.77	2	78	3.00	1	2	0.08	1
Clay	238	9.15	4	297	11.42	4	2	0.08	1
Clinton	94	3.62	2	120	4.62	2	0	0.00	1
Cole	72	2.77	1	103	3.96	2	8	0.31	4
Cooper	54	2.08	1	100	3.85	2	1	0.04	1
Crawford	87	3.35	2	103	3.96	2	0	0.00	1
Dade	108	4.15	2	118	4.54	2	1	0.04	1
Dallas	118	4.54	2	120	4.62	2	3	0.12	2
Daviess	105	4.04	2	131	5.04	3	1	0.04	1

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
DeKalb	61	2.35	1	105	4.04	2	0	0.00	1
Dent	77	2.96	1	93	3.58	2	1	0.04	1
Douglas	195	7.50	3	167	6.42	3	7	0.27	4
Dunklin	135	5.19	2	102	3.92	2	1	0.04	1
Franklin	221	8.50	3	205	7.88	4	2	0.08	1
Gasconade	87	3.35	2	100	3.85	2	1	0.04	1
Gentry	49	1.88	1	72	2.77	1	0	0.00	1
Greene	611	23.50	5	448	17.23	5	13	0.50	5
Grundy	108	4.15	2	136	5.23	3	0	0.00	1
Harrison	80	3.08	1	116	4.46	2	0	0.00	1
Henry	74	2.85	1	110	4.23	2	0	0.00	1
Hickory	92	3.54	2	89	3.42	2	1	0.04	1
Holt	42	1.62	1	92	3.54	2	0	0.00	1
Howard	34	1.31	1	74	2.85	1	0	0.00	1
Howell	228	8.77	3	215	8.27	4	5	0.19	3
Iron	71	2.73	1	51	1.96	1	1	0.04	1
Jackson	349	13.42	4	447	17.19	5	8	0.31	4
Jasper	261	10.04	4	242	9.31	4	17	0.65	5
Jefferson	147	5.65	3	208	8.00	4	8	0.31	4
Johnson	165	6.35	3	225	8.65	4	1	0.04	1
Knox	50	1.92	1	42	1.62	1	0	0.00	1
Laclede	163	6.27	3	181	6.96	3	6	0.23	3
Lafayette	97	3.73	2	116	4.46	2	0	0.00	1
Lawrence	156	6.00	3	185	7.12	3	0	0.00	1
Lewis	85	3.27	1	92	3.54	2	3	0.12	2
Lincoln	129	4.96	2	95	3.65	2	1	0.04	1
Linn	67	2.58	1	81	3.12	1	0	0.00	1
Livingston	63	2.42	1	87	3.35	2	0	0.00	1
Macon	77	2.96	1	104	4.00	2	0	0.00	1
Madison	55	2.12	1	30	1.15	1	0	0.00	1
Maries	62	2.38	1	69	2.65	1	0	0.00	1
Marion	79	3.04	1	84	3.23	2	4	0.15	2
McDonald	126	4.85	2	154	5.92	3	1	0.04	1
Mercer	46	1.77	1	74	2.85	1	0	0.00	1
Miller	96	3.69	2	128	4.92	2	0	0.00	1
Mississippi	73	2.81	1	36	1.38	1	3	0.12	2

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Moniteau	70	2.69	1	62	2.38	1	1	0.04	1
Monroe	70	2.69	1	52	2.00	1	0	0.00	1
Montgomery	80	3.08	1	89	3.42	2	0	0.00	1
Morgan	115	4.42	2	142	5.46	3	1	0.04	1
New Madrid	75	2.88	1	48	1.85	1	0	0.00	1
Newton	178	6.85	3	266	10.23	4	2	0.08	1
Nodaway	121	4.65	2	176	6.77	3	1	0.04	1
Oregon	92	3.54	2	91	3.50	2	0	0.00	1
Osage	55	2.12	1	76	2.92	1	0	0.00	1
Ozark	158	6.08	3	153	5.88	3	3	0.12	2
Pemiscot	96	3.69	2	56	2.15	1	1	0.04	1
Perry	76	2.92	1	44	1.69	1	2	0.08	1
Pettis	120	4.62	2	131	5.04	3	3	0.12	2
Phelps	114	4.38	2	138	5.31	3	5	0.19	3
Pike	102	3.92	2	77	2.96	1	1	0.04	1
Platte	151	5.81	3	244	9.38	4	1	0.04	1
Polk	216	8.31	3	209	8.04	4	0	0.00	1
Pulaski	138	5.31	2	152	5.85	3	2	0.08	1
Putnam	37	1.42	1	54	2.08	1	0	0.00	1
Ralls	78	3.00	1	57	2.19	1	3	0.12	2
Randolph	79	3.04	1	73	2.81	1	0	0.00	1
Ray	62	2.38	1	76	2.92	1	2	0.08	1
Reynolds	51	1.96	1	48	1.85	1	2	0.08	1
Ripley	81	3.12	1	82	3.15	2	0	0.00	1
Saline	49	1.88	1	82	3.15	2	0	0.00	1
Schuyler	23	0.88	1	29	1.12	1	0	0.00	1
Scotland	84	3.23	1	84	3.23	2	4	0.15	2
Scott	105	4.04	2	80	3.08	1	4	0.15	2
Shannon	123	4.73	2	112	4.31	2	0	0.00	1
Shelby	53	2.04	1	42	1.62	1	5	0.19	3
St. Charles	288	11.08	4	224	8.62	4	6	0.23	3
St. Clair	99	3.81	2	126	4.85	2	2	0.08	1
St. Francois	111	4.27	2	82	3.15	2	3	0.12	2
St. Louis City	89	3.42	2	58	2.23	1	5	0.19	3
St. Louis	396	15.23	4	388	14.92	5	16	0.62	5
Ste. Genevieve	70	2.69	1	48	1.85	1	5	0.19	3

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Stoddard	112	4.31	2	93	3.58	2	3	0.12	2
Stone	159	6.12	3	209	8.04	4	7	0.27	4
Sullivan	53	2.04	1	68	2.62	1	0	0.00	1
Taney	204	7.85	3	175	6.73	3	4	0.15	2
Texas	123	4.73	2	179	6.88	3	4	0.15	2
Vernon	167	6.42	3	168	6.46	3	1	0.04	1
Warren	83	3.19	1	79	3.04	1	3	0.12	2
Washington	82	3.15	1	137	5.27	3	0	0.00	1
Wayne	69	2.65	1	85	3.27	2	2	0.08	1
Webster	195	7.50	3	188	7.23	3	2	0.08	1
Worth	23	0.88	1	67	2.58	1	0	0.00	1
Wright	156	6.00	3	164	6.31	3	7	0.27	4

Table A.29 provides the annualized property loss and associated vulnerability ratings for severe thunderstorms.

Table A.29. Annualized Property Loss and Associated Ratings

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Adair	$6,865	1	$769	1	$7,692	3
Andrew	$4,154	1	$0	1	$0	1
Atchison	$7,192	1	$0	1	$0	1
Audrain	$1,308	1	$0	1	$0	1
Barry	$232,115	3	$41,538	1	$385	1
Barton	$419,673	4	$2,538	1	$385	1
Bates	$2,435	1	$265,077	3	$77	1
Benton	$29,500	1	$5,808	1	$577	1
Bollinger	$391,962	4	$57,692	2	$385	1
Boone	$4,923	1	$0	1	$24,423	4
Buchanan	$48,808	2	$385	1	$0	1
Butler	$449,692	4	$52,154	2	$385	1
Caldwell	$7,154	1	$962	1	$0	1
Callaway	$21,615	1	$6,000	1	$2,692	2
Camden	$60,135	2	$13,154	1	$0	1
Cape Girardeau	$303,231	3	$14,115	1	$2,385	2
Carroll	$12,038	1	$0	1	$0	1
Carter	$99,000	2	$3,231	1	$0	1
Cass	$22,481	1	$1,538	1	$962	1
Cedar	$290,577	3	$11,731	1	$2,115	2
Chariton	$2,192	1	$115	1	$0	1
Christian	$438,019	4	$1,125	1	$27,692	4
Clark	$26,115	1	$86,019	2	$9,615	3
Clay	$63,808	2	$68,096	2	$38	1
Clinton	$4,990	1	$0	1	$0	1
Cole	$40,192	1	$115,385	2	$1,346	1
Cooper	$3,923	1	$385	1	$192	1
Crawford	$5,654	1	$0	1	$0	1
Dade	$54,750	2	$1,346	1	$2,115	2
Dallas	$144,538	2	$4,442	1	$154	1
Daviess	$4,856	1	$21,731	1	$192	1
DeKalb	$579	1	$385	1	$0	1

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Dent	$49,865	2	$865	1	$1,538	1
Douglas	$238,769	3	$14,673	1	$4,692	2
Dunklin	$53,558	2	$3,593	1	$38	1
Franklin	$8,000	1	$21,154	1	$0	1
Gasconade	$1,923	1	$38,462	1	$4,808	2
Gentry	$4,979	1	$215,385	3	$0	1
Greene	$724,312	4	$135,288	2	$30,846	4
Grundy	$2,562	1	$11,538	1	$0	1
Harrison	$4,731	1	$5,192	1	$0	1
Henry	$5,254	1	$38	1	$0	1
Hickory	$164,135	3	$4,346	1	$385	1
Holt	$24,115	1	$3,923	1	$0	1
Howard	$11,654	1	$1,923	1	$0	1
Howell	$169,692	3	$11,962	1	$388	1
Iron	$1,192	1	$4	1	$0	1
Jackson	$503,529	4	$377,885	3	$12,538	3
Jasper	$247,173	3	$112,500	2	$48,000	5
Jefferson	$5,077	1	$2,077	1	$2,000	2
Johnson	$12,837	1	$2,538	1	$615	1
Knox	$0	1	$0	1	$0	1
Laclede	$85,692	2	$12,327	1	$21,135	4
Lafayette	$8,731	1	$12,500	1	$0	1
Lawrence	$221,808	3	$240,769	3	$0	1
Lewis	$462	1	$1,154	1	$0	1
Lincoln	$2,500	1	$0	1	$0	1
Linn	$5,154	1	$57,692	2	$0	1
Livingston	$24,752	1	$11,538	1	$0	1
Macon	$6,471	1	$38	1	$0	1
Madison	$9,846	1	$0	1	$0	1
Maries	$11,038	1	$192	1	$0	1
Marion	$5,000	1	$38,462	1	$969	1
McDonald	$33,423	1	$31,385	1	$385	1
Mercer	$2,538	1	$962	1	$0	1
Miller	$11,404	1	$2,808	1	$0	1
Mississippi	$266,654	3	$7,692	1	$3,462	2
Moniteau	$385	1	$0	1	$7,692	3

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Monroe	$2,885	1	$385	1	$0	1
Montgomery	$1,827	1	$0	1	$0	1
Morgan	$16,423	1	$4,231	1	$577	1
New Madrid	$476,250	4	$231	1	$0	1
Newton	$169,827	3	$8,154	1	$2,038	2
Nodaway	$75,200	2	$192	1	$0	1
Oregon	$49,846	2	$769	1	$0	1
Osage	$692	1	$0	1	$0	1
Ozark	$142,077	2	$2,558	1	$10,423	3
Pemiscot	$53,231	2	$2,229	1	$0	1
Perry	$2,006,385	5	$231,154	3	$38	1
Pettis	$18,779	1	$76,923	2	$1,538	1
Phelps	$27,769	1	$0	1	$8,923	3
Pike	$1,462	1	$0	1	$385	1
Platte	$19,923	1	$51,538	2	$3,846	2
Polk	$315,712	3	$25,019	1	$0	1
Pulaski	$33,712	1	$1,231	1	$962	1
Putnam	$11,038	1	$0	1	$0	1
Ralls	$50,808	2	$0	1	$0	1
Randolph	$15,604	1	$0	1	$0	1
Ray	$18,692	1	$0	1	$385	1
Reynolds	$231	1	$0	1	$2,115	2
Ripley	$287,885	3	$577	1	$0	1
Saline	$1,769	1	$3,462	1	$0	1
Schuyler	$2,885	1	$0	1	$0	1
Scotland	$17,792	1	$138,908	2	$10,577	3
Scott	$420,962	4	$27,500	1	$5,385	2
Shannon	$128,462	2	$835	1	$0	1
Shelby	$385	1	$0	1	$6,038	2
St. Charles	$98,385	2	$7,846,346	4	$19,308	4
St. Clair	$20,308	1	$385	1	$692	1
St. Francois	$14,231	1	$0	1	$0	1
St. Louis City	$44,000	2	$28,846	1	$192	1
St. Louis	$35,538	1	$32,787,692	5	$15,192	3
Ste. Genevieve	$769	1	$0	1	$269	1
Stoddard	$464,808	4	$4,462	1	$846	1

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Stone	$154,846	3	$10,385	1	$40,192	5
Sullivan	$5,173	1	$115	1	$0	1
Taney	$72,000	2	$47,077	2	$30,000	4
Texas	$59,750	2	$32,385	1	$3,269	2
Vernon	$34,000	1	$22,538	1	$692	1
Warren	$1,808	1	$0	1	$0	1
Washington	$423	1	$0	1	$0	1
Wayne	$166,615	3	$6,538	1	$0	1
Webster	$252,812	3	$2,510	1	$327	1
Worth	$404	1	$0	1	$0	1
Wright	$178,865	3	$43,173	1	$3,231	2

Table A.30 provides the combined vulnerability rating for thunderstorms.

Table A.30. Thunderstorm Vulnerability Ratings

County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Adair	15	1	Low
Andrew	13	1	Low
Atchison	15	1	Low
Audrain	16	1	Low
Barry	23	3	Medium
Barton	20	3	Medium
Bates	18	2	Medium Low
Benton	19	2	Medium Low
Bollinger	18	2	Medium Low
Boone	25	4	Medium High
Buchanan	18	2	Medium Low
Butler	22	3	Medium
Caldwell	15	1	Low
Callaway	22	3	Medium
Camden	21	3	Medium
Cape Girardeau	24	4	Medium High
Carroll	15	1	Low
Carter	18	2	Medium Low
Cass	19	2	Medium Low
Cedar	21	3	Medium
Chariton	15	1	Low
Christian	29	4	Medium High
Clark	18	2	Medium Low
Clay	24	4	Medium High
Clinton	15	1	Low
Cole	19	2	Medium Low
Cooper	13	1	Low
Crawford	17	2	Medium Low
Linn	16	1	Low
Livingston	15	1	Low
Macon	16	1	Low
Madison	15	1	Low
Maries	15	1	Low
Marion	17	2	Medium Low
McDonald	19	2	Medium Low
Mercer	15	1	Low
Miller	17	2	Medium Low
Mississippi	18	2	Medium Low
Moniteau	14	1	Low
Monroe	15	1	Low
Montgomery	16	1	Low
Morgan	19	2	Medium Low
New Madrid	19	2	Medium Low
Newton	23	3	Medium
Nodaway	17	2	Medium Low
Oregon	19	2	Medium Low
Osage	11	1	Low
Ozark	23	3	Medium
Pemiscot	18	2	Medium Low
Perry	18	2	Medium Low
Pettis	19	2	Medium Low
Phelps	21	3	Medium
Pike	14	1	Low
Platte	20	3	Medium
Polk	21	3	Medium
Pulaski	16	1	Low

County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Dade	18	2	Medium Low
Dallas	19	2	Medium Low
Daviess	17	2	Medium Low
DeKalb	14	1	Low
Dent	18	2	Medium Low
Douglas	25	4	Medium High
Dunklin	19	2	Medium Low
Franklin	21	3	Medium
Gasconade	17	2	Medium Low
Gentry	17	2	Medium Low
Greene	36	5	High
Grundy	17	2	Medium Low
Harrison	16	1	Low
Henry	15	1	Low
Hickory	22	3	Medium
Holt	14	1	Low
Howard	14	1	Low
Howell	25	4	Medium High
Iron	16	1	Low
Jackson	36	5	High
Jasper	33	5	High
Jefferson	24	4	Medium High
Johnson	18	2	Medium Low
Knox	15	1	Low
Laclede	26	4	Medium High
Lafayette	16	1	Low
Lawrence	23	3	Medium
Lewis	17	2	Medium Low
Lincoln	16	1	Low

County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Putnam	13	1	Low
Ralls	16	1	Low
Randolph	13	1	Low
Ray	12	1	Low
Reynolds	17	2	Medium Low
Ripley	20	3	Medium
Saline	14	1	Low
Schuyler	14	1	Low
Scotland	19	2	Medium Low
Scott	21	3	Medium
Shannon	18	2	Medium Low
Shelby	17	2	Medium Low
St. Charles	30	5	High
St. Clair	19	2	Medium Low
St. Francois	19	2	Medium Low
St. Louis City	25	4	Medium High
St. Louis	35	5	High
Ste. Genevieve	15	1	Low
Stoddard	20	3	Medium
Stone	31	5	High
Sullivan	15	1	Low
Taney	28	4	Medium High
Texas	21	3	Medium
Vernon	19	2	Medium Low
Warren	15	1	Low
Washington	18	2	Medium Low
Wayne	20	3	Medium
Webster	19	2	Medium Low
Worth	14	1	Low
Wright	25	4	Medium High

Table A.31 provides the annualized property loss and annualized property loss ratio for severe thunderstorms for each Missouri County.

Table A.31. Annualized Severe Thunderstorm Damages in Missouri

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
Adair	$6,865	0.0000026	$769	0.00000029	$7,692	0.000002866
Andrew	$4,154	0.0000023	$0	0.00000000	$0	0.000000000
Atchison	$7,192	0.0000085	$0	0.00000000	$0	0.000000000
Audrain	$1,308	0.0000005	$0	0.00000000	$0	0.000000000
Barry	$232,115	0.0000628	$41,538	0.00001123	$385	0.000000104
Barton	$419,673	0.0002802	$2,538	0.00000170	$385	0.000000257
Bates	$2,435	0.0000014	$265,077	0.00014925	$77	0.000000043
Benton	$29,500	0.0000118	$5,808	0.00000232	$577	0.000000231
Bollinger	$391,962	0.0003678	$57,692	0.00005414	$385	0.000000361
Boone	$4,923	0.0000003	$0	0.00000000	$24,423	0.000001285
Buchanan	$48,808	0.0000044	$385	0.00000003	$0	0.000000000
Butler	$449,692	0.0001060	$52,154	0.00001230	$385	0.000000091
Caldwell	$7,154	0.0000069	$962	0.00000093	$0	0.000000000
Callaway	$21,615	0.0000048	$6,000	0.00000132	$2,692	0.000000593
Camden	$60,135	0.0000070	$13,154	0.00000154	$0	0.000000000
Cape Girardeau	$303,231	0.0000335	$14,115	0.00000156	$2,385	0.000000264
Carroll	$12,038	0.0000096	$0	0.00000000	$0	0.000000000
Carter	$99,000	0.0001870	$3,231	0.00000610	$0	0.000000000
Cass	$22,481	0.0000019	$1,538	0.00000013	$962	0.000000079
Cedar	$290,577	0.0002171	$11,731	0.00000877	$2,115	0.000001581
Chariton	$2,192	0.0000023	$115	0.00000012	$0	0.000000000
Christian	$438,019	0.0000573	$1,125	0.00000015	$27,692	0.000003623
Clark	$26,115	0.0000348	$86,019	0.00011472	$9,615	0.000012824
Clay	$63,808	0.0000021	$68,096	0.00000225	$38	0.000000001
Clinton	$4,990	0.0000020	$0	0.00000000	$0	0.000000000
Cole	$40,192	0.0000036	$115,385	0.00001026	$1,346	0.000000120
Cooper	$3,923	0.0000021	$385	0.00000021	$192	0.000000104
Crawford	$5,654	0.0000022	$0	0.00000000	$0	0.000000000

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
Dade	$54,750	0.0000730	$1,346	0.00000180	$2,115	0.000002821
Dallas	$144,538	0.0001057	$4,442	0.00000325	$154	0.000000113
Daviess	$4,856	0.0000048	$21,731	0.00002161	$192	0.000000191
DeKalb	$579	0.0000005	$385	0.00000034	$0	0.000000000
Dent	$49,865	0.0000324	$865	0.00000056	$1,538	0.000001001
Douglas	$238,769	0.0002259	$14,673	0.00001388	$4,692	0.000004439
Dunklin	$53,558	0.0000176	$3,593	0.00000118	$38	0.000000013
Franklin	$8,000	0.0000006	$21,154	0.00000168	$0	0.000000000
Gasconade	$1,923	0.0000009	$38,462	0.00001887	$4,808	0.000002359
Gentry	$4,979	0.0000068	$215,385	0.00029318	$0	0.000000000
Greene	$724,312	0.0000225	$135,288	0.00000420	$30,846	0.000000957
Grundy	$2,562	0.0000021	$11,538	0.00000935	$0	0.000000000
Harrison	$4,731	0.0000043	$5,192	0.00000477	$0	0.000000000
Henry	$5,254	0.0000020	$38	0.00000001	$0	0.000000000
Hickory	$164,135	0.0001867	$4,346	0.00000494	$385	0.000000438
Holt	$24,115	0.0000364	$3,923	0.00000592	$0	0.000000000
Howard	$11,654	0.0000105	$1,923	0.00000174	$0	0.000000000
Howell	$169,692	0.0000469	$11,962	0.00000331	$388	0.000000107
Iron	$1,192	0.0000011	$4	0.00000000	$0	0.000000000
Jackson	$503,529	0.0000052	$377,885	0.00000391	$12,538	0.000000130
Jasper	$247,173	0.0000203	$112,500	0.00000925	$48,000	0.000003948
Jefferson	$5,077	0.0000002	$2,077	0.00000008	$2,000	0.000000081
Johnson	$12,837	0.0000020	$2,538	0.00000040	$615	0.000000097
Knox	$0	0.0000000	$0	0.00000000	$0	0.000000000
Laclede	$85,692	0.0000253	$12,327	0.00000365	$21,135	0.000006250
Lafayette	$8,731	0.0000021	$12,500	0.00000298	$0	0.000000000
Lawrence	$221,808	0.0000632	$240,769	0.00006856	$0	0.000000000
Lewis	$462	0.0000004	$1,154	0.00000109	$0	0.000000000
Lincoln	$2,500	0.0000005	$0	0.00000000	$0	0.000000000
Linn	$5,154	0.0000032	$57,692	0.00003556	$0	0.000000000
Livingston	$24,752	0.0000138	$11,538	0.00000645	$0	0.000000000
Macon	$6,471	0.0000038	$38	0.00000002	$0	0.000000000

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
Madison	$9,846	0.0000081	$0	0.00000000	$0	0.000000000
Maries	$11,038	0.0000111	$192	0.00000019	$0	0.000000000
Marion	$5,000	0.0000015	$38,462	0.00001137	$969	0.000000286
McDonald	$33,423	0.0000197	$31,385	0.00001846	$385	0.000000226
Mercer	$2,538	0.0000059	$962	0.00000225	$0	0.000000000
Miller	$11,404	0.0000045	$2,808	0.00000111	$0	0.000000000
Mississippi	$266,654	0.0002331	$7,692	0.00000672	$3,462	0.000003026
Moniteau	$385	0.0000002	$0	0.00000000	$7,692	0.000004943
Monroe	$2,885	0.0000029	$385	0.00000038	$0	0.000000000
Montgomery	$1,827	0.0000012	$0	0.00000000	$0	0.000000000
Morgan	$16,423	0.0000055	$4,231	0.00000142	$577	0.000000194
New Madrid	$476,250	0.0002648	$231	0.00000013	$0	0.000000000
Newton	$169,827	0.0000306	$8,154	0.00000147	$2,038	0.000000367
Nodaway	$75,200	0.0000295	$192	0.00000008	$0	0.000000000
Oregon	$49,846	0.0000546	$769	0.00000084	$0	0.000000000
Osage	$692	0.0000004	$0	0.00000000	$0	0.000000000
Ozark	$142,077	0.0001529	$2,558	0.00000275	$10,423	0.000011218
Pemiscot	$53,231	0.0000317	$2,229	0.00000133	$0	0.000000000
Perry	$2,006,385	0.0008857	$231,154	0.00010204	$38	0.000000017
Pettis	$18,779	0.0000041	$76,923	0.00001689	$1,538	0.000000338
Phelps	$27,769	0.0000056	$0	0.00000000	$8,923	0.000001790
Pike	$1,462	0.0000007	$0	0.00000000	$385	0.000000194
Platte	$19,923	0.0000016	$51,538	0.00000414	$3,846	0.000000309
Polk	$315,712	0.0001163	$25,019	0.00000922	$0	0.000000000
Pulaski	$33,712	0.0000061	$1,231	0.00000022	$962	0.000000174
Putnam	$11,038	0.0000199	$0	0.00000000	$0	0.000000000
Ralls	$50,808	0.0000414	$0	0.00000000	$0	0.000000000
Randolph	$15,604	0.0000063	$0	0.00000000	$0	0.000000000
Ray	$18,692	0.0000068	$0	0.00000000	$385	0.000000139
Reynolds	$231	0.0000003	$0	0.00000000	$2,115	0.000002942
Ripley	$287,885	0.0002510	$577	0.00000050	$0	0.000000000
Saline	$1,769	0.0000007	$3,462	0.00000140	$0	0.000000000

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
Schuyler	$2,885	0.0000070	$0	0.00000000	$0	0.000000000
Scotland	$17,792	0.0000316	$138,908	0.00024693	$10,577	0.000018802
Scott	$420,962	0.0001017	$27,500	0.00000664	$5,385	0.000001301
Shannon	$128,462	0.0001765	$835	0.00000115	$0	0.000000000
Shelby	$385	0.0000005	$0	0.00000000	$6,038	0.000007236
St. Charles	$98,385	0.0000022	$7,846,346	0.00017461	$19,308	0.000000430
St. Clair	$20,308	0.0000199	$385	0.00000038	$692	0.000000678
St. Francois	$14,231	0.0000021	$0	0.00000000	$0	0.000000000
St. Louis City	$44,000	0.0000009	$28,846	0.00000057	$192	0.000000004
St. Louis	$35,538	0.0000002	$32,787,692	0.00021354	$15,192	0.000000099
Ste. Genevieve	$769	0.0000003	$0	0.00000000	$269	0.000000118
Stoddard	$464,808	0.0001522	$4,462	0.00000146	$846	0.000000277
Stone	$154,846	0.0000397	$10,385	0.00000266	$40,192	0.000010305
Sullivan	$5,173	0.0000080	$115	0.00000018	$0	0.000000000
Taney	$72,000	0.0000116	$47,077	0.00000757	$30,000	0.000004826
Texas	$59,750	0.0000251	$32,385	0.00001358	$3,269	0.000001371
Vernon	$34,000	0.0000142	$22,538	0.00000938	$692	0.000000288
Warren	$1,808	0.0000005	$0	0.00000000	$0	0.000000000
Washington	$423	0.0000002	$0	0.00000000	$0	0.000000000
Wayne	$166,615	0.0001311	$6,538	0.00000514	$0	0.000000000
Webster	$252,812	0.0000913	$2,510	0.00000091	$327	0.000000118
Worth	$404	0.0000014	$0	0.00000000	$0	0.000000000
Wright	$178,865	0.0001105	$43,173	0.00002668	$3,231	0.000001996

Severe Winter Weather – State Vulnerability Tables

Table A.32 provides the factors considered for severe winter weather and the ranges for the rating values assigned.

Table A.32. Ranges for Severe Winter Weather Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Common Factors					
Housing Density (# per sq. mile)	4-46	47-140	141-283	284-871	872-2,865
Building Exposure ($1,000)	$286,351-$3,053,773	$3,381,480-$9,044,465	$11,043,270-$24,814,360	$30,225,497-$50,440,776	$96,532,305-$153,542,314
Social Vulnerability	1	2	3	4	5
Likelihood of Occurrence (# of events/ yrs. of data)	1-1.5	1.6-1.8	1.9-2.2	2.3-2.7	2.8-4
Average Annual Property Loss (annual property loss/ yrs. of data)	0	$1-$329,423	$329,424-$961,962	$961,963-$2,572,692	$2,572,693-$4,738,269

Once the individual ratings were determined for the above factors, a combined vulnerability rating was computed for severe winter weather events. **Table A.33** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to severe winter weather.

Table A.33. Ranges for Severe Winter Weather Combined Vulnerability Rating

	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Severe Winter Weather Combined Vulnerability	6-8	9-10	11-12	13-15	16-21

Table A.34 presents the factors considered for severe winter weather for each Missouri County.

Table A.34. Housing Density, Building Exposure, and SOVI Data by County

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Adair	$2,684,103,000	1	20.53	1	Medium	3
Andrew	$1,833,402,000	1	16.91	1	Medium Low	2
Atchison	$845,407,000	1	5.39	1	Medium High	4
Audrain	$2,802,758,000	1	15.79	1	Medium High	4
Barry	$3,698,931,000	2	22.69	1	Medium	3
Barton	$1,497,507,000	1	9.44	1	Medium	3
Bates	$1,776,058,000	1	9.37	1	Medium	3
Benton	$2,500,952,000	1	20.27	1	Medium High	4
Bollinger	$1,065,618,000	1	9.51	1	Medium Low	2
Boone	$19,011,341,000	3	115.78	2	Low	1
Buchanan	$11,043,270,000	3	95.14	2	Medium	3
Butler	$4,240,466,000	2	28.60	1	Medium High	4
Caldwell	$1,038,687,000	1	11.10	1	Medium	3
Callaway	$4,541,285,000	2	22.83	1	Medium Low	2
Camden	$8,555,313,000	2	64.15	2	Medium High	4
Cape Girardeau	$9,044,465,000	2	60.45	2	Medium	3
Carroll	$1,255,053,000	1	6.69	1	Medium	3
Carter	$529,336,000	1	6.44	1	Medium High	4
Cass	$12,120,597,000	3	61.53	2	Low	1
Cedar	$1,338,216,000	1	15.31	1	Medium High	4
Chariton	$961,579,000	1	5.52	1	Medium High	4
Christian	$7,643,064,000	2	62.76	2	Medium Low	2
Clark	$749,824,000	1	6.95	1	Medium Low	2
Clay	$30,225,497,000	4	250.91	3	Medium Low	2
Clinton	$2,458,398,000	1	21.69	1	Medium	3
Cole	$11,244,484,000	3	85.39	2	Medium Low	2
Cooper	$1,844,606,000	1	13.27	1	Medium Low	2
Crawford	$2,565,695,000	1	16.30	1	Medium	3
Dade	$749,772,000	1	8.07	1	Medium	3
Dallas	$1,367,145,000	1	14.21	1	Medium	3
Daviess	$1,005,674,000	1	7.43	1	Medium	3
DeKalb	$1,137,449,000	1	10.34	1	Low	1
Dent	$1,537,144,000	1	9.74	1	Medium High	4
Douglas	$1,057,018,000	1	8.01	1	Medium	3
Dunklin	$3,039,549,000	1	26.71	1	High	5

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Franklin	$12,583,890,000	3	49.73	2	Medium Low	2
Gasconade	$2,038,105,000	1	15.78	1	Medium	3
Gentry	$734,656,000	1	6.53	1	Medium High	4
Greene	$32,216,001,000	4	200.86	3	Medium	3
Grundy	$1,234,611,000	1	11.49	1	Medium High	4
Harrison	$1,087,927,000	1	6.06	1	Medium High	4
Henry	$2,668,413,000	1	15.76	1	Medium	3
Hickory	$879,093,000	1	17.25	1	High	5
Holt	$662,533,000	1	6.03	1	Medium	3
Howard	$1,106,490,000	1	9.90	1	Medium Low	2
Howell	$3,615,730,000	2	19.78	1	Medium	3
Iron	$1,043,899,000	1	9.64	1	Medium High	4
Jackson	$96,532,305,000	5	543.08	4	Medium	3
Jasper	$12,158,441,000	3	81.85	2	Medium	3
Jefferson	$24,814,360,000	3	140.32	2	Low	1
Johnson	$6,312,436,000	2	27.01	1	Low	1
Knox	$461,629,000	1	4.52	1	Medium High	4
Laclede	$3,381,480,000	2	21.04	1	Medium	3
Lafayette	$4,199,028,000	2	23.66	1	Medium Low	2
Lawrence	$3,511,788,000	2	27.33	1	Medium	3
Lewis	$1,054,161,000	1	9.00	1	Medium	3
Lincoln	$5,005,508,000	2	35.07	1	Low	1
Linn	$1,622,177,000	1	10.37	1	Medium High	4
Livingston	$1,789,759,000	1	12.90	1	Medium High	4
Macon	$1,687,915,000	1	9.59	1	Medium High	4
Madison	$1,216,520,000	1	12.11	1	Medium High	4
Maries	$995,884,000	1	8.75	1	Medium	3
Marion	$3,384,001,000	2	30.00	1	Medium High	4
McDonald	$1,699,965,000	1	18.53	1	Medium	3
Mercer	$426,966,000	1	4.68	1	Medium High	4
Miller	$2,529,668,000	1	21.89	1	Medium High	4
Mississippi	$1,144,050,000	1	13.93	1	Medium High	4
Moniteau	$1,556,217,000	1	14.88	1	Medium Low	2
Monroe	$1,002,707,000	1	7.49	1	Medium	3
Montgomery	$1,486,338,000	1	11.71	1	Medium High	4
Morgan	$2,974,448,000	1	26.11	1	Medium High	4
New Madrid	$1,798,374,000	1	12.76	1	High	5
Newton	$5,552,640,000	2	39.79	1	Medium Low	2

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Nodaway	$2,548,598,000	1	11.19	1	Medium	3
Oregon	$912,583,000	1	6.93	1	Medium High	4
Osage	$1,653,491,000	1	11.06	1	Low	1
Ozark	$929,161,000	1	7.66	1	Medium	3
Pemiscot	$1,677,658,000	1	16.58	1	High	5
Perry	$2,265,290,000	1	18.70	1	Medium Low	2
Pettis	$4,555,540,000	2	26.72	1	Medium	3
Phelps	$4,986,304,000	2	30.62	1	Medium Low	2
Pike	$1,977,682,000	1	11.83	1	Medium Low	2
Platte	$12,439,139,000	3	101.95	2	Low	1
Polk	$2,714,054,000	1	21.44	1	Medium	3
Pulaski	$5,518,913,000	2	35.06	1	Low	1
Putnam	$554,649,000	1	5.75	1	Medium	3
Ralls	$1,228,558,000	1	11.06	1	Medium Low	2
Randolph	$2,487,755,000	1	22.43	1	Medium Low	2
Ray	$2,767,612,000	1	17.84	1	Medium Low	2
Reynolds	$718,939,000	1	4.98	1	Medium High	4
Ripley	$1,146,993,000	1	10.55	1	Medium High	4
Saline	$2,472,916,000	1	13.47	1	Medium	3
Schuyler	$414,534,000	1	6.83	1	Medium	3
Scotland	$562,547,000	1	5.43	1	Medium High	4
Scott	$4,139,364,000	2	41.29	1	Medium	3
Shannon	$728,024,000	1	4.16	1	Medium	3
Shelby	$834,550,000	1	6.39	1	Medium	3
St. Charles	$44,937,555,000	4	282.62	3	Low	1
St. Clair	$1,021,125,000	1	8.43	1	Medium High	4
St. Francois	$6,688,219,000	2	67.37	2	Medium Low	2
St. Louis City	$50,440,776,000	4	2865.50	5	High	5
St. Louis	$153,542,314,000	5	871.01	4	Medium Low	2
Ste. Genevieve	$2,288,166,000	1	17.55	1	Medium Low	2
Stoddard	$3,053,773,000	1	16.70	1	Medium	3
Stone	$3,900,275,000	2	46.11	1	Medium High	4
Sullivan	$648,402,000	1	5.15	1	Medium High	4
Taney	$6,216,495,000	2	49.36	2	High	5
Texas	$2,384,744,000	1	9.97	1	Medium	3
Vernon	$2,402,354,000	1	11.61	1	Medium High	4
Warren	$3,695,873,000	2	37.43	1	Medium Low	2
Washington	$1,919,481,000	1	14.58	1	Medium	3

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Wayne	$1,271,311,000	1	10.69	1	Medium High	4
Webster	$2,768,483,000	1	25.12	1	Medium Low	2
Worth	$286,351,000	1	4.76	1	Medium High	4
Wright	$1,618,341,000	1	12.74	1	Medium	3

Table A.35 provides the additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis and the total overall vulnerability rating for severe winter weather. The total number of winter weather events includes blizzard, heavy snow, ice storm, winter storm, and winter weather events.

Table A.35. Additional Statistical Data Compiled for Vulnerability Analysis

County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Adair	49	1.88	3	$9,808	1	9	Medium Low
Andrew	44	1.69	2	$23,077	1	7	Low
Atchison	43	1.65	2	$7,769	1	9	Medium Low
Audrain	48	1.85	3	$0	1	10	Medium Low
Barry	43	1.65	2	$167,885	2	10	Medium Low
Barton	37	1.42	1	$308,654	2	8	Low
Bates	38	1.46	1	$22,423	1	7	Low
Benton	39	1.50	1	$14,423	1	8	Low
Bollinger	99	3.81	5	$86,538	1	10	Medium Low
Boone	52	2.00	3	$49,692	1	10	Medium Low
Buchanan	42	1.62	2	$962	1	11	Medium
Butler	87	3.35	5	$800,000	3	15	Medium High
Caldwell	42	1.62	2	$8,077	1	8	Low
Callaway	44	1.69	2	$44,962	1	8	Low
Camden	40	1.54	2	$4,634,423	5	15	Medium High
Cape Girardeau	101	3.88	5	$138,462	2	14	Medium High
Carroll	39	1.50	1	$9,615	1	7	Low
Carter	91	3.50	5	$53,846	1	12	Medium
Cass	52	2.00	3	$280,769	2	11	Medium
Cedar	39	1.50	1	$71,538	1	8	Low
Chariton	37	1.42	1	$7,692	1	8	Low
Christian	42	1.62	2	$27,500	1	9	Medium Low
Clark	105	4.04	5	$673	1	10	Medium Low
Clay	49	1.88	3	$10,462	1	13	Medium High
Clinton	46	1.77	2	$7,885	1	8	Low
Cole	44	1.69	2	$14,538	1	10	Medium Low
Cooper	33	1.27	1	$38,654	1	6	Low
Crawford	45	1.73	2	$29,000	1	8	Low
Dade	37	1.42	1	$31,731	1	7	Low
Dallas	40	1.54	2	$4,048,654	5	12	Medium
Daviess	54	2.08	3	$13,462	1	9	Medium Low

County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
DeKalb	49	1.88	3	$13,462	1	7	Low
Dent	36	1.38	1	$6,346	1	8	Low
Douglas	40	1.54	2	$10,962	1	8	Low
Dunklin	58	2.23	3	$961,962	3	13	Medium High
Franklin	51	1.96	3	$20,538	1	11	Medium
Gasconade	47	1.81	2	$5,269	1	8	Low
Gentry	45	1.73	2	$58,654	1	9	Medium Low
Greene	51	1.96	3	$4,738,269	5	18	High
Grundy	49	1.88	3	$115,577	1	10	Medium Low
Harrison	49	1.88	3	$10,577	1	10	Medium Low
Henry	46	1.77	2	$9,885	1	8	Low
Hickory	35	1.35	1	$611,923	3	11	Medium
Holt	36	1.38	1	$32,692	1	7	Low
Howard	27	1.04	1	$38,654	1	6	Low
Howell	37	1.42	1	$13,846	1	8	Low
Iron	36	1.38	1	$3,769	1	8	Low
Jackson	65	2.50	4	$654,231	3	19	High
Jasper	43	1.65	2	$219,038	2	12	Medium
Jefferson	51	1.96	3	$0	1	10	Medium Low
Johnson	44	1.69	2	$7,692	1	7	Low
Knox	45	1.73	2	$0	1	9	Medium Low
Laclede	40	1.54	2	$1,939,808	4	12	Medium
Lafayette	45	1.73	2	$15,385	1	8	Low
Lawrence	42	1.62	2	$213,462	2	10	Medium Low
Lewis	45	1.73	2	$0	1	8	Low
Lincoln	53	2.04	3	$0	1	8	Low
Linn	41	1.58	2	$4,038	1	9	Medium Low
Livingston	41	1.58	2	$4,231	1	9	Medium Low
Macon	38	1.46	1	$8,269	1	8	Low
Madison	34	1.31	1	$0	1	8	Low
Maries	36	1.38	1	$151,154	2	8	Low
Marion	48	1.85	3	$0	1	11	Medium
McDonald	33	1.27	1	$12,885	1	7	Low
Mercer	46	1.77	2	$19,615	1	9	Medium Low
Miller	34	1.31	1	$2,572,692	4	11	Medium
Mississippi	69	2.65	4	$796,154	3	13	Medium High

County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Moniteau	45	1.73	2	$7,692	1	7	Low
Monroe	47	1.81	2	$0	1	8	Low
Montgomery	47	1.81	2	$231	1	9	Medium Low
Morgan	36	1.38	1	$8,681	1	8	Low
New Madrid	70	2.69	4	$835,000	3	14	Medium High
Newton	37	1.42	1	$1,560,385	4	10	Medium Low
Nodaway	48	1.85	3	$7,692	1	9	Medium Low
Oregon	30	1.15	1	$5,769	1	8	Low
Osage	43	1.65	2	$3,923	1	6	Low
Ozark	32	1.23	1	$8,654	1	7	Low
Pemiscot	53	2.04	3	$961,962	3	13	Medium High
Perry	98	3.77	5	$24,385	1	10	Medium Low
Pettis	41	1.58	2	$4,346	1	9	Medium Low
Phelps	37	1.42	1	$210,385	2	8	Low
Pike	46	1.77	2	$0	1	7	Low
Platte	56	2.15	3	$209,692	2	11	Medium
Polk	41	1.58	2	$55,769	1	8	Low
Pulaski	37	1.42	1	$329,423	2	7	Low
Putnam	50	1.92	3	$19,423	1	9	Medium Low
Ralls	50	1.92	3	$0	1	8	Low
Randolph	33	1.27	1	$19,615	1	6	Low
Ray	40	1.54	2	$11,538	1	7	Low
Reynolds	33	1.27	1	$4,615	1	8	Low
Ripley	86	3.31	5	$588,462	3	14	Medium High
Saline	36	1.38	1	$17,385	1	7	Low
Schuyler	49	1.88	3	$86,731	1	9	Medium Low
Scotland	105	4.04	5	$942	1	12	Medium
Scott	85	3.27	5	$836,692	3	14	Medium High
Shannon	37	1.42	1	$6,346	1	7	Low
Shelby	45	1.73	2	$0	1	8	Low
St. Charles	53	2.04	3	$775,731	3	14	Medium High
St. Clair	35	1.35	1	$59,231	1	8	Low
St. Francois	37	1.42	1	$45,962	1	8	Low
St. Louis City	51	1.96	3	$2,011,538	4	21	High
St. Louis	54	2.08	3	$1,684,615	4	18	High
Ste. Genevieve	37	1.42	1	$20,346	1	6	Low

County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Stoddard	86	3.31	5	$788,462	3	13	Medium High
Stone	39	1.50	1	$17,308	1	9	Medium Low
Sullivan	47	1.81	2	$29,231	1	9	Medium Low
Taney	36	1.38	1	$16,154	1	11	Medium
Texas	41	1.58	2	$12,692	1	8	Low
Vernon	35	1.35	1	$42,885	1	8	Low
Warren	49	1.88	3	$3,692	1	9	Medium Low
Washington	43	1.65	2	$12,115	1	8	Low
Wayne	96	3.69	5	$82,692	1	12	Medium
Webster	47	1.81	2	$231,346	2	8	Low
Worth	46	1.77	2	$10,577	1	9	Medium Low
Wright	44	1.69	2	$17,500	1	8	Low

Table A.36 provides the annualized property loss for severe winter weather for each Missouri County.

Table A.36. Annualized Severe Winter Weather Damages in Missouri

County	Annualized Blizzard Property Loss ($)	Annualized Heavy Snow Property Loss ($)	Annualized Ice Storm Property Loss ($)	Annualized Winter Storm Property Loss ($)	Annualized Winter Weather Property Loss ($)	Total Annualized Winter Weather Property Loss ($)
Adair	$0	$7,692	$192	$0	$1,923	$9,808
Andrew	$0	$3,846	$19,231	$0	$0	$23,077
Atchison	$0	$3,846	$3,846	$77	$0	$7,769
Audrain	$0	$0	$0	$0	$0	$0
Barry	$0	$577	$159,615	$7,692	$0	$167,885
Barton	$0	$3,077	$269,615	$35,962	$0	$308,654
Bates	$0	$38	$22,385	$0	$0	$22,423
Benton	$0	$192	$13,269	$962	$0	$14,423
Bollinger	$0	$0	$5,769	$80,769	$0	$86,538
Boone	$0	$0	$25,115	$24,577	$0	$49,692
Buchanan	$0	$0	$962	$0	$0	$962
Butler	$0	$0	$3,846	$796,154	$0	$800,000
Caldwell	$0	$0	$385	$7,692	$0	$8,077
Callaway	$0	$0	$0	$44,962	$0	$44,962
Camden	$0	$769	$9,615	$4,618,269	$5,769	$4,634,423
Cape Girardeau	$0	$0	$1,923	$136,538	$0	$138,462
Carroll	$0	$0	$9,615	$0	$0	$9,615
Carter	$0	$0	$3,846	$50,000	$0	$53,846
Cass	$0	$0	$257,692	$0	$23,077	$280,769
Cedar	$0	$577	$68,077	$2,885	$0	$71,538
Chariton	$0	$0	$7,692	$0	$0	$7,692
Christian	$0	$1,346	$19,231	$6,731	$192	$27,500
Clark	$0	$0	$577	$0	$96	$673
Clay	$0	$9,615	$846	$0	$0	$10,462
Clinton	$0	$0	$192	$7,692	$0	$7,885
Cole	$0	$0	$1,308	$13,231	$0	$14,538
Cooper	$0	$0	$38,654	$0	$0	$38,654
Crawford	$0	$0	$29,000	$0	$0	$29,000
Dade	$0	$577	$28,846	$2,308	$0	$31,731
Dallas	$0	$577	$4,044,231	$3,846	$0	$4,048,654
Daviess	$0	$3,846	$9,615	$0	$0	$13,462
DeKalb	$0	$3,846	$9,615	$0	$0	$13,462
Dent	$0	$192	$0	$6,154	$0	$6,346
Douglas	$0	$385	$5,577	$4,808	$192	$10,962
Dunklin	$0	$116	$961,731	$116	$0	$961,962

County	Annualized Blizzard Property Loss ($)	Annualized Heavy Snow Property Loss ($)	Annualized Ice Storm Property Loss ($)	Annualized Winter Storm Property Loss ($)	Annualized Winter Weather Property Loss ($)	Total Annualized Winter Weather Property Loss ($)
Franklin	$0	$0	$12,846	$7,692	$0	$20,538
Gasconade	$0	$0	$5,269	$0	$0	$5,269
Gentry	$0	$57,692	$962	$0	$0	$58,654
Greene	$1,538	$10,577	$4,694,231	$8,846	$23,077	$4,738,269
Grundy	$0	$115,385	$192	$0	$0	$115,577
Harrison	$0	$9,615	$962	$0	$0	$10,577
Henry	$0	$192	$7,769	$0	$1,923	$9,885
Hickory	$0	$385	$29,808	$581,731	$0	$611,923
Holt	$0	$3,846	$28,846	$0	$0	$32,692
Howard	$0	$0	$38,654	$0	$0	$38,654
Howell	$0	$0	$4,038	$9,615	$192	$13,846
Iron	$0	$0	$0	$3,769	$0	$3,769
Jackson	$0	$38,462	$576,923	$0	$38,846	$654,231
Jasper	$0	$2,308	$203,846	$9,038	$3,846	$219,038
Jefferson	$0	$0	$0	$0	$0	$0
Johnson	$0	$0	$7,692	$0	$0	$7,692
Knox	$0	$0	$0	$0	$0	$0
Laclede	$0	$1,923	$1,933,077	$962	$3,846	$1,939,808
Lafayette	$0	$0	$11,538	$0	$3,846	$15,385
Lawrence	$577	$1,923	$205,769	$5,192	$0	$213,462
Lewis	$0	$0	$0	$0	$0	$0
Lincoln	$0	$0	$0	$0	$0	$0
Linn	$0	$0	$192	$3,846	$0	$4,038
Livingston	$0	$0	$385	$3,846	$0	$4,231
Macon	$0	$0	$7,885	$0	$385	$8,269
Madison	$0	$0	$0	$0	$0	$0
Maries	$0	$192	$130,769	$20,192	$0	$151,154
Marion	$0	$0	$0	$0	$0	$0
McDonald	$2,308	$1,154	$7,500	$1,923	$0	$12,885
Mercer	$0	$19,231	$385	$0	$0	$19,615
Miller	$0	$385	$118,077	$2,454,231	$0	$2,572,692
Mississippi	$0	$0	$0	$796,154	$0	$796,154
Moniteau	$0	$0	$0	$7,692	$0	$7,692
Monroe	$0	$0	$0	$0	$0	$0
Montgomery	$0	$0	$231	$0	$0	$231
Morgan	$0	$192	$3,385	$5,104	$0	$8,681
New Madrid	$0	$0	$0	$835,000	$0	$835,000
Newton	$962	$577	$1,550,000	$6,731	$2,115	$1,560,385

County	Annualized Blizzard Property Loss ($)	Annualized Heavy Snow Property Loss ($)	Annualized Ice Storm Property Loss ($)	Annualized Winter Storm Property Loss ($)	Annualized Winter Weather Property Loss ($)	Total Annualized Winter Weather Property Loss ($)
Nodaway	$0	$3,846	$3,846	$0	$0	$7,692
Oregon	$0	$0	$0	$5,769	$0	$5,769
Osage	$0	$0	$3,923	$0	$0	$3,923
Ozark	$0	$3,846	$0	$4,808	$0	$8,654
Pemiscot	$0	$116	$961,731	$116	$0	$961,962
Perry	$0	$0	$5,769	$18,462	$154	$24,385
Pettis	$0	$0	$4,038	$308	$0	$4,346
Phelps	$0	$1,346	$194,615	$14,423	$0	$210,385
Pike	$0	$0	$0	$0	$0	$0
Platte	$0	$9,615	$192,385	$0	$7,692	$209,692
Polk	$0	$1,923	$48,077	$5,769	$0	$55,769
Pulaski	$0	$769	$323,462	$5,192	$0	$329,423
Putnam	$0	$19,231	$192	$0	$0	$19,423
Ralls	$0	$0	$0	$0	$0	$0
Randolph	$0	$0	$19,231	$0	$385	$19,615
Ray	$0	$0	$11,538	$0	$0	$11,538
Reynolds	$0	$0	$0	$4,615	$0	$4,615
Ripley	$0	$0	$3,846	$584,615	$0	$588,462
Saline	$0	$0	$15,462	$0	$1,923	$17,385
Schuyler	$0	$86,538	$192	$0	$0	$86,731
Scotland	$0	$0	$846	$0	$96	$942
Scott	$0	$0	$1,923	$834,769	$0	$836,692
Shannon	$0	$0	$192	$6,154	$0	$6,346
Shelby	$0	$0	$0	$0	$0	$0
St. Charles	$0	$0	$6,500	$769,231	$0	$775,731
St. Clair	$0	$385	$11,731	$47,115	$0	$59,231
St. Francois	$0	$0	$0	$45,962	$0	$45,962
St. Louis City	$0	$0	$0	$2,011,538	$0	$2,011,538
St. Louis	$0	$0	$3,846	$1,680,769	$0	$1,684,615
Ste. Genevieve	$0	$0	$0	$20,346	$0	$20,346
Stoddard	$0	$0	$3,846	$784,615	$0	$788,462
Stone	$0	$577	$15,385	$1,154	$192	$17,308
Sullivan	$0	$28,846	$385	$0	$0	$29,231
Taney	$0	$769	$15,385	$0	$0	$16,154
Texas	$0	$577	$5,962	$6,154	$0	$12,692
Vernon	$0	$962	$36,538	$5,385	$0	$42,885
Warren	$0	$0	$3,692	$0	$0	$3,692
Washington	$0	$0	$0	$12,115	$0	$12,115

County	Annualized Blizzard Property Loss ($)	Annualized Heavy Snow Property Loss ($)	Annualized Ice Storm Property Loss ($)	Annualized Winter Storm Property Loss ($)	Annualized Winter Weather Property Loss ($)	Total Annualized Winter Weather Property Loss ($)
Wayne	$0	$0	$5,769	$76,923	$0	$82,692
Webster	$0	$3,654	$211,923	$15,769	$0	$231,346
Worth	$0	$9,615	$962	$0	$0	$10,577
Wright	$0	$385	$10,577	$6,538	$0	$17,500

Tornadoes – State Vulnerability Tables

Table A.37 provides the factors considered for tornadoes and the ranges for the rating values assigned.

Table A.37. Ranges for Tornado Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Common Factors					
Building Exposure ($1,000)	$286,351-$3,053,773	$3,381,480-$9,044,465	$11,043,270-$24,814,360	$30,225,497-$50,440,776	$96,532,305-$153,542,314
Population Density (#per sq. mile)	8-113	114-434	435-1,163	1,164-1,958	1,959-4,855
Social Vulnerability	1	2	3	4	5
Percent Mobile Homes	0.23-4.38	4.39-8.24	8.25-13	13.01-23.77	23.78-34.58
Likelihood of Occurrence (# of events/ yrs. of data)	0-19	20-29	30-40	41-53	54-74
Total Annualized Property Loss ($ / yrs. of data)	$906-$268,132	$268,133-$1,010,663	$1,010,664-$2,400,000	$2,400,001-$4,499,038	$4,499,039-$39,592,934

Once the individual ratings were determined for the above factors, a combined vulnerability rating was computed for tornado events. **Table A.38** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to tornadoes.

Table A.38. Ranges for Tornado Combined Vulnerability Rating

	Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Tornado Combined Vulnerability	7-10	11-12	13-14	15-16	17-21

Table A.39 provides the building exposure, population density, SOVI index ranking and percentage of mobile homes by county and associated vulnerability rating.

Table A.39. Building Exposure, Population Density, SOVI, and Mobile Home Data by County

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Adair	$2,684,103,000	1	44.67	1	Medium	3	5.7	2
Andrew	$1,833,402,000	1	40.93	1	Medium Low	2	6.7	2
Atchison	$845,407,000	1	9.40	1	Medium High	4	2.2	1
Audrain	$2,802,758,000	1	36.68	1	Medium High	4	4.9	2
Barry	$3,698,931,000	2	45.99	1	Medium	3	18.3	4
Barton	$1,497,507,000	1	19.86	1	Medium	3	10.2	3
Bates	$1,776,058,000	1	19.33	1	Medium	3	11.7	3
Benton	$2,500,952,000	1	27.62	1	Medium High	4	17.8	5
Bollinger	$1,065,618,000	1	19.64	1	Medium Low	2	12.4	4
Boone	$19,011,341,000	3	263.29	2	Low	1	4.1	1
Buchanan	$11,043,270,000	3	214.11	2	Medium	3	4.2	1
Butler	$4,240,466,000	2	61.15	1	Medium High	4	13.0	3
Caldwell	$1,038,687,000	1	21.15	1	Medium	3	10.3	4
Callaway	$4,541,285,000	2	53.61	1	Medium Low	2	13.7	4
Camden	$8,555,313,000	2	70.60	1	Medium High	4	11.1	2
Cape Girardeau	$9,044,465,000	2	136.33	2	Medium	3	6.5	2
Carroll	$1,255,053,000	1	12.49	1	Medium	3	7.1	3
Carter	$529,336,000	1	11.79	1	Medium High	4	17.9	5
Cass	$12,120,597,000	3	151.80	2	Low	1	4.3	2
Cedar	$1,338,216,000	1	30.24	1	Medium High	4	15.6	4
Chariton	$961,579,000	1	9.89	1	Medium High	4	10.1	3
Christian	$7,643,064,000	2	157.46	2	Medium Low	2	4.9	2
Clark	$749,824,000	1	13.47	1	Medium Low	2	15.7	4
Clay	$30,225,497,000	4	629.12	3	Medium Low	2	1.8	1
Clinton	$2,458,398,000	1	48.66	1	Medium	3	4.3	2
Cole	$11,244,484,000	3	194.91	2	Medium Low	2	2.0	1
Cooper	$1,844,606,000	1	31.36	1	Medium Low	2	5.9	2
Crawford	$2,565,695,000	1	32.21	1	Medium	3	15.1	4
Dade	$749,772,000	1	15.43	1	Medium	3	15.3	3
Dallas	$1,367,145,000	1	31.21	1	Medium	3	19.7	4
Daviess	$1,005,674,000	1	14.70	1	Medium	3	9.6	3
DeKalb	$1,137,449,000	1	29.78	1	Low	1	9.2	4
Dent	$1,537,144,000	1	20.69	1	Medium High	4	18.0	4
Douglas	$1,057,018,000	1	16.21	1	Medium	3	13.9	4
Dunklin	$3,039,549,000	1	53.84	1	High	5	9.6	3
Franklin	$12,583,890,000	3	112.68	1	Medium Low	2	8.7	3
Gasconade	$2,038,105,000	1	28.40	1	Medium	3	7.9	3
Gentry	$734,656,000	1	13.37	1	Medium High	4	4.0	3
Greene	$32,216,001,000	4	434.01	2	Medium	3	3.4	1
Grundy	$1,234,611,000	1	22.63	1	Medium High	4	5.5	2
Harrison	$1,087,927,000	1	11.56	1	Medium High	4	6.5	3

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Henry	$2,668,413,000	1	31.31	1	Medium	3	11.4	3
Hickory	$879,093,000	1	23.91	1	High	5	34.6	5
Holt	$662,533,000	1	9.52	1	Medium	3	9.8	2
Howard	$1,106,490,000	1	21.56	1	Medium Low	2	11.1	4
Howell	$3,615,730,000	2	43.26	1	Medium	3	15.2	4
Iron	$1,043,899,000	1	18.40	1	Medium High	4	16.6	4
Jackson	$96,532,305,000	5	1163.04	3	Medium	3	1.0	1
Jasper	$12,158,441,000	3	190.02	2	Medium	3	6.4	2
Jefferson	$24,814,360,000	3	342.78	2	Low	1	9.9	3
Johnson	$6,312,436,000	2	65.19	1	Low	1	8.2	3
Knox	$461,629,000	1	7.86	1	Medium High	4	8.7	3
Laclede	$3,381,480,000	2	46.71	1	Medium	3	16.5	4
Lafayette	$4,199,028,000	2	52.05	1	Medium Low	2	7.0	3
Lawrence	$3,511,788,000	2	62.70	1	Medium	3	10.2	3
Lewis	$1,054,161,000	1	19.36	1	Medium	3	13.9	4
Lincoln	$5,005,508,000	2	94.19	1	Low	1	14.9	4
Linn	$1,622,177,000	1	19.36	1	Medium High	4	6.1	3
Livingston	$1,789,759,000	1	28.60	1	Medium High	4	6.7	2
Macon	$1,687,915,000	1	18.87	1	Medium High	4	21.5	3
Madison	$1,216,520,000	1	24.45	1	Medium High	4	11.1	3
Maries	$995,884,000	1	16.50	1	Medium	3	9.7	4
Marion	$3,384,001,000	2	65.30	1	Medium High	4	13.9	2
McDonald	$1,699,965,000	1	42.33	1	Medium	3	4.4	5
Mercer	$426,966,000	1	7.97	1	Medium High	4	3.9	3
Miller	$2,529,668,000	1	43.23	1	Medium High	4	13.7	3
Mississippi	$1,144,050,000	1	32.02	1	Medium High	4	7.0	2
Moniteau	$1,556,217,000	1	38.87	1	Medium Low	2	6.7	2
Monroe	$1,002,707,000	1	13.35	1	Medium	3	16.0	4
Montgomery	$1,486,338,000	1	21.54	1	Medium High	4	12.5	3
Morgan	$2,974,448,000	1	34.51	1	Medium High	4	17.8	4
New Madrid	$1,798,374,000	1	25.30	1	High	5	13.8	3
Newton	$5,552,640,000	2	93.21	1	Medium Low	2	13.8	4
Nodaway	$2,548,598,000	1	25.19	1	Medium	3	6.8	2
Oregon	$912,583,000	1	13.33	1	Medium High	4	16.9	4
Osage	$1,653,491,000	1	22.53	1	Low	1	6.4	2
Ozark	$929,161,000	1	12.31	1	Medium	3	19.3	4
Pemiscot	$1,677,658,000	1	32.09	1	High	5	7.3	3
Perry	$2,265,290,000	1	40.34	1	Medium Low	2	7.1	2
Pettis	$4,555,540,000	2	62.06	1	Medium	3	5.1	2
Phelps	$4,986,304,000	2	66.35	1	Medium Low	2	9.2	3
Pike	$1,977,682,000	1	27.30	1	Medium Low	2	10.6	3
Platte	$12,439,139,000	3	248.50	2	Low	1	0.4	1
Polk	$2,714,054,000	1	50.59	1	Medium	3	11.6	3
Pulaski	$5,518,913,000	2	96.16	1	Low	1	9.1	3
Putnam	$554,649,000	1	9.08	1	Medium	3	8.7	2
Ralls	$1,228,558,000	1	21.94	1	Medium Low	2	8.7	4

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Randolph	$2,487,755,000	1	51.27	1	Medium Low	2	12.0	3
Ray	$2,767,612,000	1	40.47	1	Medium Low	2	4.3	2
Reynolds	$718,939,000	1	7.76	1	Medium High	4	16.1	4
Ripley	$1,146,993,000	1	21.11	1	Medium High	4	22.3	5
Saline	$2,472,916,000	1	30.13	1	Medium	3	7.1	2
Schuyler	$414,534,000	1	15.16	1	Medium	3	12.7	3
Scotland	$562,547,000	1	11.23	1	Medium High	4	9.4	2
Scott	$4,139,364,000	2	91.15	1	Medium	3	11.2	3
Shannon	$728,024,000	1	8.13	1	Medium	3	18.1	4
Shelby	$834,550,000	1	11.84	1	Medium	3	11.1	3
St. Charles	$44,937,555,000	4	717.33	3	Low	1	2.7	1
St. Clair	$1,021,125,000	1	14.03	1	Medium High	4	20.4	5
St. Francois	$6,688,219,000	2	148.74	2	Medium Low	2	10.4	4
St. Louis City	$50,440,776,000	4	4855.05	5	High	5	0.4	1
St. Louis	$153,542,314,000	5	1957.87	4	Medium Low	2	0.2	1
Ste. Genevieve	$2,288,166,000	1	35.85	1	Medium Low	2	9.5	3
Stoddard	$3,053,773,000	1	35.26	1	Medium	3	9.2	3
Stone	$3,900,275,000	2	68.86	1	Medium High	4	13.7	4
Sullivan	$648,402,000	1	9.40	1	Medium High	4	10.4	3
Taney	$6,216,495,000	2	88.43	1	High	5	14.8	3
Texas	$2,384,744,000	1	21.57	1	Medium	3	16.0	4
Vernon	$2,402,354,000	1	24.88	1	Medium High	4	10.6	3
Warren	$3,695,873,000	2	83.18	1	Medium Low	2	14.7	3
Washington	$1,919,481,000	1	32.54	1	Medium	3	33.1	5
Wayne	$1,271,311,000	1	16.96	1	Medium High	4	23.8	5
Webster	$2,768,483,000	1	66.82	1	Medium Low	2	10.6	3
Worth	$286,351,000	1	7.55	1	Medium High	4	6.1	2
Wright	$1,618,341,000	1	26.83	1	Medium	3	15.3	4

Table A.40 provides additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis and the total overall vulnerability rating for tornadoes.

Table A.40. Likelihood of Occurrence, Annual Property Loss, and Overall Vulnerability Rating for Tornadoes

County	Total Number of Tornadoes	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Adair	10	0.139	1	$72,226	1	9	Low
Andrew	23	0.319	3	$89,824	1	10	Low
Atchison	18	0.250	2	$9,167	1	10	Low
Audrain	23	0.319	3	$8,091	1	12	Medium Low
Barry	46	0.639	5	$303,028	2	17	High
Barton	38	0.528	4	$630,255	2	14	Medium
Bates	24	0.333	3	$18,758	1	12	Medium Low
Benton	25	0.347	3	$72,918	1	15	Medium High
Bollinger	26	0.361	3	$83,653	1	12	Medium Low
Boone	33	0.458	4	$483,480	2	13	Medium
Buchanan	23	0.319	3	$58,962	1	13	Medium
Butler	42	0.583	5	$597,313	2	17	High
Caldwell	11	0.153	1	$42,535	1	11	Medium Low
Callaway	40	0.556	5	$12,191	1	15	Medium High
Camden	25	0.347	3	$112,677	1	13	Medium
Cape Girardeau	43	0.597	5	$252,813	1	15	Medium High
Carroll	16	0.222	2	$44,174	1	11	Medium Low
Carter	16	0.222	2	$335,236	2	15	Medium High
Cass	40	0.556	5	$436,762	2	15	Medium High
Cedar	19	0.264	2	$920,865	2	14	Medium
Chariton	19	0.264	2	$193,198	1	12	Medium Low
Christian	42	0.583	5	$1,370,896	3	16	Medium High
Clark	14	0.194	1	$49,385	1	10	Low
Clay	35	0.486	4	$1,586,230	3	17	High
Clinton	25	0.347	3	$5,869	1	11	Medium Low
Cole	10	0.139	1	$2,400,001	3	12	Medium Low
Cooper	18	0.250	2	$16,146	1	9	Low
Crawford	21	0.292	2	$366,892	2	13	Medium
Dade	25	0.347	3	$80,208	1	12	Medium Low
Dallas	14	0.194	1	$105,944	1	11	Medium Low
Daviess	20	0.278	2	$40,000	1	11	Medium Low
DeKalb	19	0.264	2	$10,347	1	10	Low
Dent	15	0.208	2	$11,983	1	13	Medium
Douglas	35	0.486	4	$100,285	1	14	Medium
Dunklin	35	0.486	4	$459,422	2	16	Medium High
Franklin	27	0.375	3	$26,771	1	13	Medium
Gasconade	8	0.111	1	$351,392	2	11	Medium Low
Gentry	20	0.278	2	$146,708	1	12	Medium Low
Greene	53	0.736	5	$1,597,150	3	18	High

County	Total Number of Tornadoes	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Grundy	17	0.236	2	$8,681	1	11	Medium Low
Harrison	24	0.333	3	$84,202	1	13	Medium
Henry	13	0.181	1	$11,494	1	10	Low
Hickory	16	0.222	2	$24,938	1	15	Medium High
Holt	14	0.194	1	$3,956	1	9	Low
Howard	10	0.139	1	$14,237	1	10	Low
Howell	44	0.611	5	$545,882	2	17	High
Iron	16	0.222	2	$39,278	1	13	Medium
Jackson	46	0.639	5	$161,146	1	18	High
Jasper	47	0.653	5	$39,592,934	5	20	High
Jefferson	34	0.472	4	$114,065	1	14	Medium
Johnson	34	0.472	4	$89,656	1	12	Medium Low
Knox	8	0.111	1	$10,764	1	11	Medium Low
Laclede	24	0.333	3	$208,715	1	14	Medium
Lafayette	28	0.389	3	$51,355	1	12	Medium Low
Lawrence	26	0.361	3	$544,549	2	14	Medium
Lewis	14	0.194	1	$109,444	1	11	Medium Low
Lincoln	22	0.306	3	$44,793	1	12	Medium Low
Linn	14	0.194	1	$51,459	1	11	Medium Low
Livingston	12	0.167	1	$28,612	1	10	Low
Macon	15	0.208	2	$99,462	1	12	Medium Low
Madison	28	0.389	3	$11,493	1	13	Medium
Maries	8	0.111	1	$74,656	1	11	Medium Low
Marion	12	0.167	1	$5,590	1	11	Medium Low
McDonald	24	0.333	3	$50,108	1	14	Medium
Mercer	16	0.222	2	$5,959	1	12	Medium Low
Miller	29	0.403	3	$109,865	1	13	Medium
Mississippi	26	0.361	3	$383,344	2	13	Medium
Moniteau	20	0.278	2	$353,646	2	10	Low
Monroe	23	0.319	3	$1,914	1	13	Medium
Montgomery	22	0.306	3	$24,306	1	13	Medium
Morgan	25	0.347	3	$28,723	1	14	Medium
New Madrid	35	0.486	4	$386,243	2	16	Medium High
Newton	52	0.722	5	$1,010,664	2	16	Medium High
Nodaway	33	0.458	4	$48,785	1	12	Medium Low
Oregon	19	0.264	2	$134,389	1	13	Medium
Osage	11	0.153	1	$52,781	1	7	Low
Ozark	32	0.444	4	$387,068	2	15	Medium High
Pemiscot	39	0.542	5	$877,966	2	17	High
Perry	25	0.347	3	$654,389	2	11	Medium Low
Pettis	41	0.569	5	$1,187,535	3	16	Medium High
Phelps	27	0.375	3	$129,271	1	12	Medium Low
Pike	22	0.306	3	$6,632	1	11	Medium Low
Platte	18	0.250	2	$494,515	2	11	Medium Low

County	Total Number of Tornadoes	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Polk	36	0.500	4	$177,470	1	13	Medium
Pulaski	17	0.236	2	$1,416,875	3	12	Medium Low
Putnam	8	0.111	1	$4,146	1	9	Low
Ralls	12	0.167	1	$906	1	10	Low
Randolph	9	0.125	1	$78,163	1	9	Low
Ray	32	0.444	4	$89,622	1	11	Medium Low
Reynolds	15	0.208	2	$8,368	1	13	Medium
Ripley	20	0.278	2	$64,097	1	14	Medium
Saline	24	0.333	3	$63,368	1	11	Medium Low
Schuyler	9	0.125	1	$35,664	1	10	Low
Scotland	13	0.181	1	$9,980	1	10	Low
Scott	42	0.583	5	$484,460	2	16	Medium High
Shannon	14	0.194	1	$45,521	1	11	Medium Low
Shelby	18	0.250	2	$36,563	1	11	Medium Low
St. Charles	40	0.556	5	$1,306,014	3	17	High
St. Clair	22	0.306	3	$370,986	2	16	Medium High
St. Francois	24	0.333	3	$807,604	2	15	Medium High
St. Louis City	7	0.097	1	$351,042	2	18	High
St. Louis	40	0.556	5	$4,499,039	4	21	High
Ste. Genevieve	9	0.125	1	$3,438	1	9	Low
Stoddard	42	0.583	5	$123,695	1	14	Medium
Stone	28	0.389	3	$187,222	1	15	Medium High
Sullivan	9	0.125	1	$1,221	1	11	Medium Low
Taney	20	0.278	2	$226,955	1	14	Medium
Texas	33	0.458	4	$128,751	1	14	Medium
Vernon	30	0.417	4	$485,698	2	15	Medium High
Warren	13	0.181	1	$45,771	1	10	Low
Washington	24	0.333	3	$781,944	2	15	Medium High
Wayne	21	0.292	2	$49,792	1	14	Medium
Webster	38	0.528	4	$268,133	1	12	Medium Low
Worth	12	0.167	1	$8,403	1	10	Low
Wright	25	0.347	3	$164,865	1	13	Medium

Public Health Emergency - State Vulnerability Tables

Table A.41 presents the results of the Pandemic Influenza vulnerability assessment.

Table A.41. Potential Vulnerability of Missouri Counties for Pandemic Influenza

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Adair	25,468	7,640	16.42	56.18	20.29	$87,565.20	$613,865.21	$252,620.66	**$954,051.08**	Low
Andrew	17,554	5,266	11.32	38.72	13.98	$60,354.93	$423,110.96	$174,120.59	**$657,586.48**	Low
Atchison	5,180	1,554	3.34	11.43	4.13	$17,810.10	$124,855.58	$51,381.15	**$194,046.83**	Low
Audrain	25,336	7,601	16.33	55.89	20.18	$87,111.35	$610,683.57	$251,311.34	**$949,106.25**	Low
Barry	35,615	10,685	22.96	78.56	28.37	$122,453.06	$858,442.34	$353,270.18	**$1,334,165.58**	Medium Low
Barton	11,732	3,520	7.56	25.88	9.34	$40,337.48	$282,781.01	$116,371.35	**$439,489.84**	Low
Bates	16,282	4,885	10.50	35.92	12.97	$55,981.49	$392,451.44	$161,503.44	**$609,936.38**	Low
Benton	19,305	5,792	12.45	42.58	15.38	$66,375.30	$465,316.00	$191,489.00	**$723,180.30**	Low
Bollinger	12,181	3,654	7.85	26.87	9.70	$41,881.25	$293,603.43	$120,825.05	**$456,309.73**	Low
Boone	179,704	53,911	115.86	396.40	143.14	$617,866.20	$4,331,476.14	$1,782,509.18	**$6,731,851.52**	Medium
Buchanan	87,904	26,371	56.67	193.90	70.02	$302,235.40	$2,118,784.66	$871,932.11	**$3,292,952.16**	Medium
Butler	42,570	12,771	27.45	93.90	33.91	$146,366.05	$1,026,081.44	$422,257.80	**$1,594,705.29**	Medium Low
Caldwell	9,052	2,716	5.84	19.97	7.21	$31,122.98	$218,183.91	$89,788.06	**$339,094.96**	Low
Callaway	44,944	13,483	28.98	99.14	35.80	$154,528.44	$1,083,302.90	$445,805.84	**$1,683,637.17**	Medium Low
Camden	45,823	13,747	29.54	101.08	36.50	$157,550.65	$1,104,489.78	$454,524.76	**$1,716,565.20**	Medium Low
Cape Girardeau	78,834	23,650	50.83	173.90	62.79	$271,050.53	$1,900,166.88	$781,965.50	**$2,953,182.91**	Medium
Carroll	8,723	2,617	5.62	19.24	6.95	$29,991.80	$210,253.90	$86,524.66	**$326,770.36**	Low
Carter	6,085	1,826	3.92	13.42	4.85	$20,921.71	$146,669.15	$60,357.97	**$227,948.83**	Low
Cass	104,687	31,406	67.49	230.92	83.39	$359,939.45	$2,523,311.90	$1,038,405.04	**$3,921,656.39**	Medium
Cedar	14,144	4,243	9.12	31.20	11.27	$48,630.52	$340,918.39	$140,296.32	**$529,845.23**	Low

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Chariton	7,449	2,235	4.80	16.43	5.93	$25,611.48	$179,546.17	$73,887.68	**$279,045.33**	Low
Christian	87,324	26,197	56.30	192.62	69.56	$300,241.22	$2,104,804.69	$866,179.00	**$3,271,224.91**	Medium
Clark	6,783	2,035	4.37	14.96	5.40	$23,321.61	$163,493.31	$67,281.53	**$254,096.45**	Low
Clay	246,480	73,944	158.91	543.70	196.33	$847,458.38	$5,941,004.31	$2,444,869.69	**$9,233,332.38**	Medium
Clinton	20,503	6,151	13.22	45.23	16.33	$70,494.32	$494,191.87	$203,372.13	**$768,058.32**	Low
Cole	76,630	22,989	49.40	169.03	61.04	$263,472.64	$1,847,043.01	$760,103.72	**$2,870,619.36**	Medium
Cooper	17,522	5,257	11.30	38.65	13.96	$60,244.91	$422,339.65	$173,803.18	**$656,387.74**	Low
Crawford	23,984	7,195	15.46	52.91	19.10	$82,462.84	$578,095.78	$237,900.66	**$898,459.28**	Low
Dade	7,571	2,271	4.88	16.70	6.03	$26,030.95	$182,486.79	$75,097.81	**$283,615.54**	Low
Dallas	16,841	5,052	10.86	37.15	13.41	$57,903.47	$405,925.24	$167,048.24	**$630,876.95**	Low
Daviess	8,294	2,488	5.35	18.30	6.61	$28,516.80	$199,913.54	$82,269.35	**$310,699.69**	Low
DeKalb	11,872	3,562	7.65	26.19	9.46	$40,818.83	$286,155.48	$117,760.03	**$444,734.35**	Low
Dent	15,518	4,655	10.00	34.23	12.36	$53,354.67	$374,036.45	$153,925.22	**$581,316.34**	Low
Douglas	13,335	4,001	8.60	29.42	10.62	$45,848.98	$321,418.75	$132,271.74	**$499,539.46**	Low
Dunklin	29,657	8,897	19.12	65.42	23.62	$101,968.00	$714,834.33	$294,171.94	**$1,110,974.27**	Medium Low
Franklin	103,629	31,089	66.81	228.59	82.54	$356,301.79	$2,497,810.51	$1,027,910.59	**$3,882,022.89**	Medium
Gasconade	14,673	4,402	9.46	32.37	11.69	$50,449.35	$353,669.09	$145,543.55	**$549,661.98**	Low
Gentry	6,576	1,973	4.24	14.51	5.24	$22,609.89	$158,503.91	$65,228.27	**$246,342.07**	Low
Greene	291,574	87,472	187.98	643.17	232.25	$1,002,502.55	$7,027,922.71	$2,892,163.41	**$10,922,588.67**	Medium
Grundy	9,885	2,966	6.37	21.80	7.87	$33,987.04	$238,262.04	$98,050.70	**$370,299.78**	Low
Harrison	8,427	2,528	5.43	18.59	6.71	$28,974.08	$203,119.29	$83,588.60	**$315,681.97**	Low
Henry	21,854	6,556	14.09	48.21	17.41	$75,139.38	$526,755.55	$216,772.89	**$818,667.83**	Low
Hickory	9,452	2,836	6.09	20.85	7.53	$32,498.28	$227,825.27	$93,755.71	**$354,079.27**	Low
Holt	4,374	1,312	2.82	9.65	3.48	$15,038.88	$105,428.24	$43,386.32	**$163,853.44**	Low
Howard	10,022	3,007	6.46	22.11	7.98	$34,458.08	$241,564.20	$99,409.62	**$375,431.91**	Low

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Howell	40,130	12,039	25.87	88.52	31.96	$137,976.73	$967,269.16	$398,055.10	**$1,503,300.99**	Medium Low
Iron	10,150	3,045	6.54	22.39	8.08	$34,898.18	$244,649.44	$100,679.27	**$380,226.89**	Low
Jackson	700,733	210,220	451.77	1,545.72	558.15	$2,409,291.02	$16,890,042.89	$6,950,668.92	**$26,250,002.83**	High
Jasper	120,528	36,158	77.71	265.87	96.00	$414,404.67	$2,905,133.75	$1,195,534.14	**$4,515,072.56**	Medium
Jefferson	224,777	67,433	144.92	495.83	179.04	$772,838.17	$5,417,888.37	$2,229,594.59	**$8,420,321.13**	Medium
Johnson	53,948	16,184	34.78	119.00	42.97	$185,486.39	$1,300,329.85	$535,117.78	**$2,020,934.01**	Medium Low
Knox	3,948	1,184	2.55	8.71	3.14	$13,574.19	$95,160.20	$39,160.77	**$147,895.15**	Low
Laclede	35,680	10,704	23.00	78.70	28.42	$122,676.55	$860,009.06	$353,914.92	**$1,336,600.53**	Medium Low
Lafayette	32,697	9,809	21.08	72.12	26.04	$112,420.26	$788,108.64	$324,326.13	**$1,224,855.03**	Medium Low
Lawrence	38,241	11,472	24.65	84.35	30.46	$131,481.89	$921,737.85	$379,317.84	**$1,432,537.58**	Medium Low
Lewis	9,898	2,969	6.38	21.83	7.88	$34,031.74	$238,575.38	$98,179.65	**$370,786.77**	Low
Lincoln	57,590	17,277	37.13	127.04	45.87	$198,008.47	$1,388,114.40	$571,243.29	**$2,157,366.16**	Medium Low
Linn	12,004	3,601	7.74	26.48	9.56	$41,272.68	$289,337.13	$119,069.36	**$449,679.17**	Low
Livingston	14,969	4,491	9.65	33.02	11.92	$51,467.07	$360,803.69	$148,479.61	**$560,750.37**	Low
Macon	15,154	4,546	9.77	33.43	12.07	$52,103.15	$365,262.82	$150,314.65	**$567,680.62**	Low
Madison	12,176	3,653	7.85	26.86	9.70	$41,864.06	$293,482.91	$120,775.45	**$456,122.42**	Low
Maries	8,791	2,637	5.67	19.39	7.00	$30,225.60	$211,892.93	$87,199.16	**$329,317.69**	Low
Marion	28,572	8,572	18.42	63.03	22.76	$98,237.51	$688,682.14	$283,409.68	**$1,070,329.33**	Medium Low
McDonald	22,882	6,865	14.75	50.47	18.23	$78,673.90	$551,533.84	$226,969.77	**$857,177.51**	Low
Mercer	3,623	1,087	2.34	7.99	2.89	$12,456.76	$87,326.59	$35,937.05	**$135,720.40**	Low
Miller	25,369	7,611	16.36	55.96	20.21	$87,224.81	$611,478.98	$251,638.67	**$950,342.46**	Low
Mississippi	13,328	3,998	8.59	29.40	10.62	$45,824.92	$321,250.02	$132,202.30	**$499,277.24**	Low
Moniteau	15,907	4,772	10.26	35.09	12.67	$54,692.15	$383,412.67	$157,783.76	**$595,888.58**	Low
Monroe	8,630	2,589	5.56	19.04	6.87	$29,672.05	$208,012.28	$85,602.18	**$323,286.51**	Low
Montgomery	11,414	3,424	7.36	25.18	9.09	$39,244.12	$275,116.13	$113,217.07	**$427,577.31**	Low

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Morgan	20,438	6,131	13.18	45.08	16.28	$70,270.83	$492,625.15	$202,727.39	**$765,623.37**	Low
New Madrid	17,275	5,183	11.14	38.11	13.76	$59,395.66	$416,386.11	$171,353.15	**$647,134.93**	Low
Newton	58,288	17,486	37.58	128.57	46.43	$200,408.36	$1,404,938.57	$578,166.85	**$2,183,513.78**	Medium Low
Nodaway	22,199	6,660	14.31	48.97	17.68	$76,325.58	$535,071.22	$220,194.99	**$831,591.79**	Low
Oregon	10,561	3,168	6.81	23.30	8.41	$36,311.29	$254,555.93	$104,756.04	**$395,623.27**	Low
Osage	13,613	4,084	8.78	30.03	10.84	$46,804.82	$328,119.49	$135,029.26	**$509,953.56**	Low
Ozark	9,138	2,741	5.89	20.16	7.28	$31,418.67	$220,256.81	$90,641.10	**$342,316.58**	Low
Pemiscot	16,330	4,899	10.53	36.02	13.01	$56,146.52	$393,608.41	$161,979.56	**$611,734.49**	Low
Perry	19,227	5,768	12.40	42.41	15.31	$66,107.12	$463,435.94	$190,715.31	**$720,258.36**	Low
Pettis	42,421	12,726	27.35	93.57	33.79	$145,853.75	$1,022,490.03	$420,779.85	**$1,589,123.63**	Medium Low
Phelps	44,587	13,376	28.75	98.35	35.51	$153,300.98	$1,074,697.98	$442,264.71	**$1,670,263.68**	Medium Low
Pike	18,158	5,447	11.71	40.05	14.46	$62,431.63	$437,669.41	$180,111.75	**$680,212.79**	Low
Platte	102,848	30,854	66.31	226.87	81.92	$353,616.52	$2,478,985.76	$1,020,163.74	**$3,852,766.02**	Medium
Polk	32,031	9,609	20.65	70.66	25.51	$110,130.39	$772,055.78	$317,719.98	**$1,199,906.16**	Medium Low
Pulaski	52,359	15,708	33.76	115.50	41.71	$180,023.02	$1,262,029.55	$519,356.27	**$1,961,408.84**	Medium Low
Putnam	4,746	1,424	3.06	10.47	3.78	$16,317.91	$114,394.70	$47,076.24	**$177,788.85**	Low
Ralls	10,258	3,077	6.61	22.63	8.17	$35,269.51	$247,252.61	$101,750.54	**$384,272.65**	Low
Randolph	24,769	7,431	15.97	54.64	19.73	$85,161.87	$597,016.94	$245,687.19	**$927,865.99**	Low
Ray	22,900	6,870	14.76	50.51	18.24	$78,735.79	$551,967.70	$227,148.31	**$857,851.80**	Low
Reynolds	6,274	1,882	4.04	13.84	5.00	$21,571.54	$151,224.69	$62,232.69	**$235,028.92**	Low
Ripley	13,484	4,045	8.69	29.74	10.74	$46,361.28	$325,010.15	$133,749.69	**$505,121.12**	Low
Saline	22,932	6,880	14.78	50.58	18.27	$78,845.81	$552,739.01	$227,465.72	**$859,050.54**	Low
Schuyler	4,550	1,365	2.93	10.04	3.62	$15,644.01	$109,670.44	$45,132.09	**$170,446.54**	Low
Scotland	4,923	1,477	3.17	10.86	3.92	$16,926.48	$118,661.00	$48,831.93	**$184,419.41**	Low
Scott	38,538	11,561	24.85	85.01	30.70	$132,503.05	$928,896.56	$382,263.83	**$1,443,663.43**	Medium Low

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Shannon	8,207	2,462	5.29	18.10	6.54	$28,217.67	$197,816.55	$81,406.38	**$307,440.60**	Low
Shelby	5,975	1,793	3.85	13.18	4.76	$20,543.51	$144,017.77	$59,266.86	**$223,828.14**	Low
St. Charles	398,472	119,542	256.90	878.97	317.39	$1,370,043.95	$9,604,527.22	$3,952,499.66	**$14,927,070.83**	Medium
St. Clair	9,455	2,837	6.10	20.86	7.53	$32,508.60	$227,897.58	$93,785.47	**$354,191.65**	Low
St. Francois	66,653	19,996	42.97	147.03	53.09	$229,169.28	$1,606,563.45	$661,140.46	**$2,496,873.19**	Medium Low
St. Louis, City	304,709	91,413	196.45	672.14	242.71	$1,047,663.88	$7,344,520.78	$3,022,451.31	**$11,414,635.98**	Medium
St. Louis	996,179	298,854	642.25	2,197.43	793.48	$3,425,106.45	$24,011,293.94	$9,881,239.24	**$37,317,639.62**	High
Ste. Genevieve	17,887	5,366	11.53	39.46	14.25	$61,499.87	$431,137.39	$177,423.66	**$670,060.92**	Low
Stoddard	29,255	8,777	18.86	64.53	23.30	$100,585.83	$705,144.76	$290,184.45	**$1,095,915.04**	Medium Low
Stone	31,875	9,563	20.55	70.31	25.39	$109,594.03	$768,295.65	$316,172.60	**$1,194,062.27**	Medium Low
Sullivan	6,163	1,849	3.97	13.59	4.91	$21,189.90	$148,549.21	$61,131.66	**$230,870.77**	Low
Taney	55,563	16,669	35.82	122.56	44.26	$191,039.15	$1,339,256.83	$551,137.19	**$2,081,433.17**	Medium Low
Texas	25,518	7,655	16.45	56.29	20.33	$87,737.11	$615,070.38	$253,116.62	**$955,924.11**	Low
Vernon	20,560	6,168	13.26	45.35	16.38	$70,690.30	$495,565.76	$203,937.52	**$770,193.58**	Low
Warren	35,090	10,527	22.62	77.40	27.95	$120,647.98	$845,788.06	$348,062.63	**$1,314,498.67**	Medium Low
Washington	24,819	7,446	16.00	54.75	19.77	$85,333.78	$598,222.11	$246,183.14	**$929,739.03**	Low
Wayne	13,058	3,917	8.42	28.80	10.40	$44,896.59	$314,742.11	$129,524.13	**$489,162.83**	Low
Webster	39,127	11,738	25.23	86.31	31.17	$134,528.17	$943,093.46	$388,106.20	**$1,465,727.83**	Medium Low
Worth	2,001	600	1.29	4.41	1.59	$6,879.93	$48,230.89	$19,848.20	**$74,959.02**	Low
Wright	18,256	5,477	11.77	40.27	14.54	$62,768.58	$440,031.54	$181,083.82	**$683,883.95**	Low

Table A.41 presents the results of the COVID-19 vulnerability assessment.

Table A.42. Vulnerability of Missouri Counties for COVID-19 Pandemic

County	Total COVID Cases	Distribution of Cases by Age Groups			Distribution of High Risk Cases by Age Group		Distribution of NOT - High Risk Cases by Age Group			Total Economic Impact ($)
		0-17	18-64	65+	18-64	65+	0-17	18-64	65+	
Adair	5,502	990	3,851	660	1,560	355	990	2,292	305	**$8,170,056**
Andrew	4,758	856	3,331	571	1,349	307	856	1,982	264	**$7,065,272**
Atchison	1,390	250	973	167	394	90	250	579	77	**$2,064,045**
Audrain	5,734	1,032	4,014	688	1,626	370	1,032	2,388	318	**$8,514,559**
Barry	6,625	1,193	4,638	795	1,878	428	1,193	2,759	367	**$9,837,627**
Barton	2,844	512	1,991	341	806	184	512	1,185	158	**$4,223,126**
Bates	3,746	674	2,622	450	1,062	242	674	1,560	208	**$5,562,528**
Benton	4,179	752	2,925	501	1,185	270	752	1,741	232	**$6,205,501**
Bollinger	2,589	466	1,812	311	734	167	466	1,078	144	**$3,844,470**
Boone	43,350	7,803	30,345	5,202	12,290	2,799	7,803	18,055	2,403	**$64,371,489**
Buchanan	22,740	4,093	15,918	2,729	6,447	1,468	4,093	9,471	1,261	**$33,767,190**
Butler	10,111	1,820	7,078	1,213	2,866	653	1,820	4,211	561	**$15,014,074**
Caldwell	1,694	305	1,186	203	480	109	305	706	94	**$2,515,463**
Callaway	12,072	2,173	8,450	1,449	3,422	779	2,173	5,028	669	**$17,926,012**
Camden	9,280	1,670	6,496	1,114	2,631	599	1,670	3,865	514	**$13,780,102**
Cape Girardeau	18,740	3,373	13,118	2,249	5,313	1,210	3,373	7,805	1,039	**$27,827,490**
Carroll	2,226	401	1,558	267	631	144	401	927	123	**$3,305,443**
Carter	1,499	270	1,049	180	425	97	270	624	83	**$2,225,902**
Cass	24,967	4,494	17,477	2,996	7,078	1,612	4,494	10,399	1,384	**$37,074,117**
Cedar	2,922	526	2,045	351	828	189	526	1,217	162	**$4,338,950**
Chariton	1,699	306	1,189	204	482	110	306	708	94	**$2,522,887**
Christian	20,868	3,756	14,608	2,504	5,916	1,347	3,756	8,692	1,157	**$30,987,410**
Clark	1,590	286	1,113	191	451	103	286	662	88	**$2,361,030**
Clay	26,987	4,858	18,891	3,238	7,651	1,742	4,858	11,240	1,496	**$40,073,665**

County	Total COVID Cases	Distribution of Cases by Age Groups			Distribution of High Risk Cases by Age Group		Distribution of NOT - High Risk Cases by Age Group			Total Economic Impact ($)
		0-17	18-64	65+	18-64	65+	0-17	18-64	65+	
Clinton	4,804	865	3,363	576	1,362	310	865	2,001	266	**$7,133,579**
Cole	20,121	3,622	14,085	2,415	5,704	1,299	3,622	8,380	1,116	**$29,878,172**
Cooper	4,141	745	2,899	497	1,174	267	745	1,725	230	**$6,149,074**
Crawford	5,396	971	3,777	648	1,530	348	971	2,247	299	**$8,012,654**
Dade	1,439	259	1,007	173	408	93	259	599	80	**$2,136,807**
Dallas	3,812	686	2,668	457	1,081	246	686	1,588	211	**$5,660,533**
Daviess	1,716	309	1,201	206	486	111	309	715	95	**$2,548,131**
DeKalb	2,204	397	1,543	264	625	142	397	918	122	**$3,272,774**
Dent	3,261	587	2,283	391	924	211	587	1,358	181	**$4,842,340**
Douglas	2,550	459	1,785	306	723	165	459	1,062	141	**$3,786,558**
Dunklin	7,456	1,342	5,219	895	2,114	481	1,342	3,105	413	**$11,071,599**
Franklin	22,675	4,082	15,873	2,721	6,428	1,464	4,082	9,444	1,257	**$33,670,669**
Gasconade	3,334	600	2,334	400	945	215	600	1,389	185	**$4,950,739**
Gentry	2,158	388	1,511	259	612	139	388	899	120	**$3,204,468**
Greene	69,975	12,596	48,983	8,397	19,838	4,518	12,596	29,145	3,879	**$103,907,612**
Grundy	2,485	447	1,740	298	704	160	447	1,035	138	**$3,690,038**
Harrison	1,821	328	1,275	219	516	118	328	758	101	**$2,704,048**
Henry	5,741	1,033	4,019	689	1,628	371	1,033	2,391	318	**$8,524,953**
Hickory	1,827	329	1,279	219	518	118	329	761	101	**$2,712,958**
Holt	1,055	190	739	127	299	68	190	439	58	**$1,566,596**
Howard	2,167	390	1,517	260	614	140	390	903	120	**$3,217,832**
Howell	9,002	1,620	6,301	1,080	2,552	581	1,620	3,749	499	**$13,367,293**
Iron	2,197	395	1,538	264	623	142	395	915	122	**$3,262,380**
Jackson	208,774	37,579	146,142	25,053	59,187	13,478	37,579	86,954	11,574	**$310,013,687**
Jasper	34,597	6,227	24,218	4,152	9,808	2,234	6,227	14,410	1,918	**$51,373,943**
Jefferson	53,990	9,718	37,793	6,479	15,306	3,486	9,718	22,487	2,993	**$80,171,089**
Johnson	12,165	2,190	8,516	1,460	3,449	785	2,190	5,067	674	**$18,064,110**

County	Total COVID Cases	Distribution of Cases by Age Groups			Distribution of High Risk Cases by Age Group		Distribution of NOT - High Risk Cases by Age Group			Total Economic Impact ($)
		0-17	18-64	65+	18-64	65+	0-17	18-64	65+	
Knox	977	176	684	117	277	63	176	407	54	**$1,450,772**
Laclede	8,102	1,458	5,671	972	2,297	523	1,458	3,374	449	**$12,030,861**
Lafayette	7,793	1,403	5,455	935	2,209	503	1,403	3,246	432	**$11,572,019**
Lawrence	7,786	1,401	5,450	934	2,207	503	1,401	3,243	432	**$11,561,624**
Lewis	2,745	494	1,922	329	778	177	494	1,143	152	**$4,076,119**
Lincoln	15,127	2,723	10,589	1,815	4,289	977	2,723	6,300	839	**$22,462,457**
Linn	2,549	459	1,784	306	723	165	459	1,062	141	**$3,785,073**
Livingston	3,751	675	2,626	450	1,063	242	675	1,562	208	**$5,569,953**
Macon	3,634	654	2,544	436	1,030	235	654	1,514	201	**$5,396,217**
Madison	3,601	648	2,521	432	1,021	232	648	1,500	200	**$5,347,214**
Maries	1,599	288	1,119	192	453	103	288	666	89	**$2,374,395**
Marion	7,961	1,433	5,573	955	2,257	514	1,433	3,316	441	**$11,821,486**
McDonald	5,353	964	3,747	642	1,518	346	964	2,230	297	**$7,948,802**
Mercer	697	125	488	84	198	45	125	290	39	**$1,034,993**
Miller	6,101	1,098	4,271	732	1,730	394	1,098	2,541	338	**$9,059,526**
Mississippi	3,457	622	2,420	415	980	223	622	1,440	192	**$5,133,385**
Moniteau	3,814	687	2,670	458	1,081	246	687	1,589	211	**$5,663,503**
Monroe	2,173	391	1,521	261	616	140	391	905	120	**$3,226,742**
Montgomery	2,500	450	1,750	300	709	161	450	1,041	139	**$3,712,312**
Morgan	4,025	725	2,818	483	1,141	260	725	1,676	223	**$5,976,822**
New Madrid	5,030	905	3,521	604	1,426	325	905	2,095	279	**$7,469,172**
Newton	11,730	2,111	8,211	1,408	3,325	757	2,111	4,886	650	**$17,418,168**
Nodaway	5,740	1,033	4,018	689	1,627	371	1,033	2,391	318	**$8,523,468**
Oregon	2,022	364	1,415	243	573	131	364	842	112	**$3,002,518**
Osage	3,212	578	2,248	385	911	207	578	1,338	178	**$4,769,578**
Ozark	1,710	308	1,197	205	485	110	308	712	95	**$2,539,221**
Pemiscot	3,006	541	2,104	361	852	194	541	1,252	167	**$4,463,684**

County	Total COVID Cases	Distribution of Cases by Age Groups			Distribution of High Risk Cases by Age Group		Distribution of NOT - High Risk Cases by Age Group			Total Economic Impact ($)
		0-17	18-64	65+	18-64	65+	0-17	18-64	65+	
Perry	4,989	898	3,492	599	1,414	322	898	2,078	277	**$7,408,290**
Pettis	12,208	2,197	8,546	1,465	3,461	788	2,197	5,085	677	**$18,127,962**
Phelps	10,185	1,833	7,130	1,222	2,887	658	1,833	4,242	565	**$15,123,959**
Pike	4,238	763	2,967	509	1,201	274	763	1,765	235	**$6,293,111**
Platte	10,378	1,868	7,265	1,245	2,942	670	1,868	4,322	575	**$15,410,549**
Polk	8,040	1,447	5,628	965	2,279	519	1,447	3,349	446	**$11,938,795**
Pulaski	8,818	1,587	6,173	1,058	2,500	569	1,587	3,673	489	**$13,094,067**
Putnam	995	179	697	119	282	64	179	414	55	**$1,477,500**
Ralls	2,455	442	1,719	295	696	158	442	1,023	136	**$3,645,490**
Randolph	6,013	1,082	4,209	722	1,705	388	1,082	2,504	333	**$8,928,853**
Ray	5,147	926	3,603	618	1,459	332	926	2,144	285	**$7,642,908**
Reynolds	1,158	208	811	139	328	75	208	482	64	**$1,719,543**
Ripley	2,690	484	1,883	323	763	174	484	1,120	149	**$3,994,448**
Saline	6,269	1,128	4,388	752	1,777	405	1,128	2,611	348	**$9,308,993**
Schuyler	735	132	515	88	208	47	132	306	41	**$1,091,420**
Scotland	681	123	477	82	193	44	123	284	38	**$1,011,234**
Scott	11,109	2,000	7,776	1,333	3,149	717	2,000	4,627	616	**$16,496,029**
Shannon	1,607	289	1,125	193	456	104	289	669	89	**$2,386,274**
Shelby	1,555	280	1,089	187	441	100	280	648	86	**$2,309,058**
St. Charles	93,814	16,887	65,670	11,258	26,596	6,057	16,887	39,074	5,201	**$139,306,734**
St. Clair	2,102	378	1,471	252	596	136	378	875	117	**$3,121,312**
St. Francois	19,070	3,433	13,349	2,288	5,406	1,231	3,433	7,943	1,057	**$28,317,516**
St. Louis, City	56,254	10,126	39,378	6,750	15,948	3,632	10,126	23,430	3,119	**$83,532,959**
St. Louis	215,940	38,869	151,158	25,913	61,219	13,941	38,869	89,939	11,972	**$320,654,658**
Ste. Genevieve	3,655	658	2,559	439	1,036	236	658	1,522	203	**$5,427,400**
Stoddard	6,103	1,099	4,272	732	1,730	394	1,099	2,542	338	**$9,062,496**

County	Total COVID Cases	Distribution of Cases by Age Groups			Distribution of High Risk Cases by Age Group		Distribution of NOT - High Risk Cases by Age Group			Total Economic Impact ($)
		0-17	18-64	65+	18-64	65+	0-17	18-64	65+	
Stone	5,784	1,041	4,049	694	1,640	373	1,041	2,409	321	**$8,588,805**
Sullivan	1,706	307	1,194	205	484	110	307	711	95	**$2,533,282**
Taney	13,307	2,395	9,315	1,597	3,773	859	2,395	5,542	738	**$19,759,894**
Texas	4,719	849	3,303	566	1,338	305	849	1,965	262	**$7,007,360**
Vernon	5,051	909	3,536	606	1,432	326	909	2,104	280	**$7,500,355**
Warren	8,133	1,464	5,693	976	2,306	525	1,464	3,387	451	**$12,076,893**
Washington	5,983	1,077	4,188	718	1,696	386	1,077	2,492	332	**$8,884,305**
Wayne	2,400	432	1,680	288	680	155	432	1,000	133	**$3,563,819**
Webster	9,025	1,625	6,318	1,083	2,559	583	1,625	3,759	500	**$13,401,446**
Worth	401	72	281	48	114	26	72	167	22	**$595,455**
Wright	3,834	690	2,684	460	1,087	248	690	1,597	213	**$5,693,202**

Structural/Urban Fire – State Vulnerability Assessment

Table A.43 provides the factors considered and the ranges for structural/urban fires and the rating values assigned.

Table A.43. Ranges for Structural and Urban Fire Vulnerability Factor Ratings

Factors Considered	Low (1)	Low Medium (2)	Medium (3)	Medium High (4)	High (5)
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Housing Density (# per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2836.23
Social Vulnerability	1	2	3	4	5
Structural and Urban Fire Likelihood of Occurrence (# of events/ yrs. of data)	0 to 49	50 to 99	100 to 299	300 to 499	500+
Total Annualized Property Loss	$0 - $1,418,838	$1,418,839 - $4,742,961	$4,742,962 - $11,010,704	$11,010,705 - $500,454,576	$500,454,577 - $3,093,587,180
Death/Injury (2X # of deaths + # of injuries)	0 to 4	5 to 9	10 to 19	20 to 49	50+

Once the ranges were determined and applied to all factors considered in the analysis, the ratings were combed to determine an overall vulnerability rating for structural and urban fire. **Table A.44** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to structural and urban fire. The figures that follow provide the mapped results of this analysis by county.

Table A.44. Ranges for Structural and Urban Fire Combined Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Structural and Urban Fire Combined Vulnerability	7-10	11-13	14-16	17-21	22-27

Table A.45 below provides the housing density, building exposure, SOVI index ranking and associated vulnerability rating.

Table A.45. Building Exposure, Housing Density, and SOVI Data by County

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
Adair	$2,599,614,000	1	19.93	1	Medium	3
Andrew	$1,724,819,000	1	16.88	1	Medium Low	2
Atchison	$806,754,000	1	5.42	1	Medium High	4
Audrain	$2,689,090,000	1	15.62	1	Medium High	4
Barry	$3,736,121,000	2	22.40	1	Medium	3
Barton	$1,414,960,000	1	9.42	1	Medium	3
Bates	$1,650,150,000	1	9.36	1	Medium	3

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
Benton	$2,478,458,000	1	19.93	1	Medium High	4
Bollinger	$1,035,129,000	1	9.45	1	Medium Low	2
Boone	$18,473,209,000	3	105.32	2	Low	1
Buchanan	$10,579,076,000	3	94.32	2	Medium	3
Butler	$4,144,110,000	2	28.30	1	Medium High	4
Caldwell	$984,103,000	1	10.80	1	Medium	3
Callaway	$4,410,445,000	2	22.21	1	Medium Low	2
Camden	$8,325,943,000	2	62.86	2	Medium High	4
Cape Girardeau	$8,792,829,000	2	56.87	2	Medium	3
Carroll	$1,199,939,000	1	6.63	1	Medium	3
Carter	$519,266,000	1	6.38	1	Medium High	4
Cass	$10,922,958,000	3	58.01	2	Low	1
Cedar	$1,307,607,000	1	15.13	1	Medium High	4
Chariton	$938,756,000	1	5.53	1	Medium High	4
Christian	$7,747,900,000	2	57.48	2	Medium Low	2
Clark	$709,999,000	1	6.84	1	Medium Low	2
Clay	$27,589,080,000	4	237.97	3	Medium Low	2
Clinton	$2,282,850,000	1	21.20	1	Medium	3
Cole	$10,724,282,000	3	82.94	2	Medium Low	2
Cooper	$1,797,081,000	1	13.21	1	Medium Low	2
Crawford	$2,389,455,000	1	16.06	1	Medium	3
Dade	$738,641,000	1	8.05	1	Medium	3
Dallas	$1,358,763,000	1	14.04	1	Medium	3
Daviess	$958,602,000	1	7.42	1	Medium	3
DeKalb	$1,090,102,000	1	10.21	1	Low	1
Dent	$1,451,544,000	1	9.65	1	Medium High	4
Douglas	$1,047,849,000	1	7.95	1	Medium	3
Dunklin	$2,976,060,000	1	26.53	1	High	5
Franklin	$11,417,093,000	3	47.40	2	Medium Low	2
Gasconade	$1,888,630,000	1	15.77	1	Medium	3
Gentry	$689,499,000	1	6.52	1	Medium High	4
Greene	$32,106,732,000	4	189.79	3	Medium	3
Grundy	$1,175,303,000	1	11.49	1	Medium High	4
Harrison	$1,024,720,000	1	6.07	1	Medium High	4
Henry	$2,536,896,000	1	15.64	1	Medium	3
Hickory	$865,580,000	1	16.92	1	High	5
Holt	$622,760,000	1	6.01	1	Medium	3
Howard	$1,086,442,000	1	9.79	1	Medium Low	2
Howell	$3,550,892,000	2	19.47	1	Medium	3
Iron	$978,688,000	1	9.62	1	Medium High	4
Jackson	$89,309,906,000	5	519.48	4	Medium	3
Jasper	$12,070,483,000	3	80.05	2	Medium	3
Jefferson	$22,249,768,000	3	134.91	2	Low	1
Johnson	$6,044,509,000	2	26.18	1	Low	1
Knox	$438,423,000	1	4.51	1	Medium High	4
Laclede	$3,218,581,000	1	20.62	1	Medium	3

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
Lafayette	$3,841,393,000	2	23.42	1	Medium Low	2
Lawrence	$3,495,760,000	2	27.09	1	Medium	3
Lewis	$995,873,000	1	8.94	1	Medium	3
Lincoln	$4,719,921,000	2	33.63	1	Low	1
Linn	$1,551,785,000	1	10.36	1	Medium High	4
Livingston	$1,711,120,000	1	12.66	1	Medium High	4
Macon	$1,634,837,000	1	9.52	1	Medium High	4
Madison	$1,135,602,000	1	12.03	1	Medium High	4
Maries	$955,863,000	1	8.71	1	Medium	3
Marion	$3,224,641,000	1	29.49	1	Medium High	4
McDonald	$1,683,620,000	1	18.26	1	Medium	3
Mercer	$401,520,000	1	4.67	1	Medium High	4
Miller	$2,404,472,000	1	21.50	1	Medium High	4
Mississippi	$1,114,534,000	1	13.86	1	Medium High	4
Moniteau	$1,508,058,000	1	14.80	1	Medium Low	2
Monroe	$979,485,000	1	7.43	1	Medium	3
Montgomery	$1,397,445,000	1	11.45	1	Medium High	4
Morgan	$2,872,295,000	1	25.80	1	Medium High	4
New Madrid	$1,765,289,000	1	12.64	1	High	5
Newton	$5,509,504,000	2	38.96	1	Medium Low	2
Nodaway	$2,447,800,000	1	10.96	1	Medium	3
Oregon	$891,037,000	1	6.89	1	Medium High	4
Osage	$1,611,790,000	1	10.85	1	Low	1
Ozark	$926,358,000	1	7.55	1	Medium	3
Pemiscot	$1,642,290,000	1	16.48	1	High	5
Perry	$2,233,009,000	1	18.14	1	Medium Low	2
Pettis	$4,468,128,000	2	26.68	1	Medium	3
Phelps	$4,743,488,000	2	29.35	1	Medium Low	2
Pike	$1,861,578,000	1	11.68	1	Medium Low	2
Platte	$11,360,168,000	3	94.90	2	Low	1
Polk	$2,708,704,000	1	20.98	1	Medium	3
Pulaski	$5,334,660,000	2	33.60	1	Low	1
Putnam	$532,020,000	1	5.73	1	Medium	3
Ralls	$1,155,646,000	1	10.93	1	Medium Low	2
Randolph	$2,425,165,000	1	22.11	1	Medium Low	2
Ray	$2,537,055,000	1	17.52	1	Medium Low	2
Reynolds	$669,647,000	1	4.97	1	Medium High	4
Ripley	$1,131,335,000	1	10.40	1	Medium High	4
Saline	$2,437,646,000	1	13.35	1	Medium	3
Schuyler	$401,800,000	1	6.79	1	Medium	3
Scotland	$541,487,000	1	5.38	1	Medium High	4
Scott	$4,036,288,000	2	40.47	1	Medium	3
Shannon	$678,728,000	1	4.11	1	Medium	3
Shelby	$786,622,000	1	6.37	1	Medium	3
St. Charles	$41,845,005,000	4	259.98	3	Low	1
St. Clair	$936,097,000	1	8.36	1	Medium High	4

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
St. Francois	$6,180,166,000	2	64.59	2	Medium Low	2
St. Louis	$138,887,850,000	5	862.69	4	Medium Low	2
St. Louis City	$46,880,213,000	4	2836.23	5	High	5
Ste. Genevieve	$2,163,144,000	1	17.27	1	Medium Low	2
Stoddard	$2,989,130,000	1	16.52	1	Medium	3
Stone	$3,936,498,000	2	44.23	1	Medium High	4
Sullivan	$624,603,000	1	5.16	1	Medium High	4
Taney	$6,120,612,000	2	47.41	2	High	5
Texas	$2,293,426,000	1	9.86	1	Medium	3
Vernon	$2,251,400,000	1	11.47	1	Medium High	4
Warren	$3,478,576,000	2	34.75	1	Medium Low	2
Washington	$1,730,986,000	1	14.34	1	Medium	3
Wayne	$1,256,590,000	1	10.54	1	Medium High	4
Webster	$2,782,115,000	1	24.42	1	Medium Low	2
Worth	$269,532,000	1	4.78	1	Medium High	4
Wright	$1,602,331,000	1	12.66	1	Medium	3

Table A.46 provides additional data obtained from the National Fire Incident Reporting System to complete the overall vulnerability analysis and the total overall vulnerability rating for structural and urban fires.

Table A.46. Likelihood of Occurrence, Annual Property Loss, Death/Injury Rating and Overall Vulnerability Rating for Structural and Urban Fires, 2002-2012

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Adair	2	1	$91,750	1	0	1	8	Low
Andrew	18	1	$43,438	1	2	1	7	Low
Atchison	24	1	$209,750	1	0	1	9	Low
Audrain	40	1	$127,354	1	0	1	9	Low
Barry	235	3	$2,348,775	2	73	5	16	Medium
Barton	68	2	$1,250	1	6	2	10	Low
Bates	65	2	$617,283	1	23	4	12	Low Medium
Benton	92	2	$600,846	1	17	3	12	Low Medium
Bollinger	32	1	$26,350	1	0	1	7	Low
Boone	250	3	$1,703,748	2	17	3	14	Medium

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Buchanan	453	4	$4,742,961	2	90	5	19	Medium High
Butler	375	1	$1,013	1	46	4	13	Low Medium
Caldwell	33	1	$190,355	1	23	4	11	Low Medium
Callaway	161	3	$933,628	1	25	4	13	Low Medium
Camden	247	3	$823,724	1	123	5	17	Medium High
Cape Girardeau	131	3	$1,018,812	1	14	3	14	Medium
Carroll	91	2	$246,388	1	192	5	13	Low Medium
Carter	3	1	$6,250	1	0	1	9	Low
Cass	314	4	$2,922,337	2	40	4	16	Medium
Cedar	101	3	$280,773	1	17	3	13	Low Medium
Chariton	39	1	$77,711	1	0	1	9	Low
Christian	318	4	$1,154,653	1	24	4	15	Medium
Clark	26	1	$199,013	1	5	2	8	Low
Clay	301	4	$2,821,315	2	56	5	20	Medium High
Clinton	133	3	$762,583	1	20	4	13	Low Medium
Cole	64	2	$338,115	1	3	1	11	Low Medium
Cooper	81	2	$1,139,950	1	17	3	10	Low
Crawford	195	3	$500,454,576	4	124	5	17	Medium High
Dade	46	1	$56,600	1	7	2	9	Low
Dallas	35	1	$385,418	1	10	3	10	Low
Daviess	69	2	$498,838	1	6	2	10	Low
DeKalb	61	2	$432,096	1	3	1	7	Low
Dent	66	2	$883,313	1	4	1	10	Low
Douglas	39	1	$481,425	1	5	2	9	Low
Dunklin	108	3	$903,143	2	10	3	15	Medium
Franklin	497	4	$2,720,556	2	34	4	17	Medium High
Gasconade	65	2	$530,075	1	5	2	10	Low
Gentry	1	1	$0	1	0	1	9	Low

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Greene	1308	5	$7,497,115	3	167	5	23	High
Grundy	98	2	$906,142	1	16	3	12	Low Medium
Harrison	41	1	$398,913	1	8	2	10	Low
Henry	149	3	$1,403,733	1	49	4	13	Low Medium
Hickory	24	1	$103,625	1	4	1	10	Low
Holt	21	1	$220,081	1	0	1	8	Low
Howard	89	2	$4,681	1	524	5	12	Low Medium
Howell	255	3	$1,589,394	2	224	5	16	Medium
Iron	61	2	$165,975	1	2	1	10	Low
Jackson	3195	5	$3,093,587,180	5	236	5	27	High
Jasper	629	5	$3,556,000	2	66	5	20	Medium High
Jefferson	632	5	$2,553,764	2	99	5	18	Medium High
Johnson	191	3	$818,586	1	36	4	12	Low Medium
Knox	7	1	$61,250	1	2	1	9	Low
Laclede	113	3	$223,308	1	75	5	14	Medium
Lafayette	162	3	$538,540	1	16	3	12	Low Medium
Lawrence	137	3	$1,223,428	1	41	4	14	Medium
Lewis	45	1	$250,225	1	0	1	8	Low
Lincoln	248	3	$1,163,485	1	14	3	11	Low Medium
Linn	49	1	$226,838	1	11	3	11	Low Medium
Livingston	39	1	$223,220	1	8	2	10	Low
Macon	33	1	$353,298	1	20	4	12	Low Medium
Madison	61	2	$500	1	3	1	10	Low
Maries	28	1	$94,725	1	2	1	8	Low
Marion	176	3	$1,086,442	1	56	5	15	Medium
McDonald	74	2	$76,838	1	5	2	10	Low
Mercer	31	1	$11,025	1	8	2	10	Low
Miller	80	2	$2,120,003	2	7	2	12	Low Medium

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Mississippi	106	3	$1,747,609	2	4	1	12	Low Medium
Moniteau	88	2	$1,201,209	1	0	1	8	Low
Monroe	36	1	$76,925	1	0	1	8	Low
Montgomery	61	2	$602,800	1	16	3	12	Low Medium
Morgan	113	3	$978,530	1	16	3	13	Low Medium
New Madrid	140	3	$1,249,658	1	42	4	15	Medium
Newton	277	3	$1,678,486	2	28	4	14	Medium
Nodaway	51	2	$704,963	1	9	2	10	Low
Oregon	66	2	$128,950	1	6	2	11	Low Medium
Osage	41	1	$194,863	1	39	4	9	Low
Ozark	83	2	$892,031	1	22	4	12	Low Medium
Pemiscot	82	2	$1,418,838	1	12	3	13	Low Medium
Perry	47	1	$738,138	1	2	1	7	Low
Pettis	190	3	$313,200	1	12	3	13	Low Medium
Phelps	201	3	$1,020,777	1	187	5	14	Medium
Pike	25	1	$22,476	1	46	4	10	Low
Platte	158	3	$666,891	1	43	4	14	Medium
Polk	69	2	$2,075	1	3	1	9	Low
Pulaski	185	3	$426,824	1	145	5	13	Low Medium
Putnam	13	1	$209,819	1	15	3	10	Low
Ralls	25	1	$3,375	1	0	1	7	Low
Randolph	139	3	$1,241,845	1	20	4	12	Low Medium
Ray	149	3	$458,450	1	9	2	10	Low
Reynolds	44	1	$112,275	1	17	3	11	Low Medium
Ripley	24	1	$144,450	1	0	1	9	Low
Saline	82	2	$686,711	1	2	1	9	Low
Schuyler	0	1	$0	1	0	1	8	Low
Scotland	30	1	$761,613	1	3	1	9	Low
Scott	222	3	$1,415,352	1	25	4	14	Medium
Shannon	64	2	$427,514	1	0	1	9	Low

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Shelby	7	1	$1,163	1	0	1	8	Low
St. Charles	676	5	$8,001,810	3	166	5	21	Medium High
St. Clair	72	2	$395,611	1	24	4	13	Low Medium
St. Francois	297	3	$1,542,971	2	29	4	15	Medium
St. Louis	1,637	5	$11,010,704	3	195	5	24	High
St. Louis City	11,647	5	$6,481,025	3	174	5	27	High
Ste. Genevieve	69	2	$484,900	1	22	4	11	Low Medium
Stoddard	139	3	$669,575	1	12	3	12	Low Medium
Stone	253	3	$187,032	1	148	5	16	Medium
Sullivan	3	1	$31,500	1	0	1	9	Low
Taney	332	4	$3,004,301	2	18	3	18	Medium High
Texas	179	3	$1,188,786	1	25	4	13	Low Medium
Vernon	77	2	$664,808	1	12	3	12	Low Medium
Warren	152	3	$937,188	1	9	2	11	Low Medium
Washington	301	4	$388,550	1	27	4	14	Medium
Wayne	17	1	$0	1	0	1	9	Low
Webster	132	3	$306,850	1	3	1	9	Low
Worth	15	1	$273,675	1	0	1	9	Low
Wright	130	3	$3,388,852	2	14	3	13	Low Medium

Repetitive Loss Data

Table A.47 presents the number of repetitive loss properties by county along with the number of NFIP claims, paid losses, and average payment amount.

Table A.47. Missouri Repetitive Loss County Summary

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
ADAIR COUNTY	**1**	**2**	**$30,029**	**$15,015**
KIRKSVILLE, CITY OF	1	2	$30,029	$15,015
ANDREW COUNTY	**19**	**48**	**$1,375,598**	**$31,180**
ANDREW COUNTY*	15	40	$1,197,229	$33,549
BUCHANAN COUNTY*	1	2	$21,334	$10,667
NOVINGER, CITY OF	1	2	$131,409	$65,704
ROSENDALE, CITY OF	2	4	$25,627	$6,407
ATCHISON COUNTY	**10**	**23**	**$551,595**	**$24,145**
ATCHISON COUNTY*	7	15	$480,178	$30,559
ROCK PORT, CITY OF	1	3	$16,868	$5,623
TARKIO, CITY OF	2	5	$54,550	$10,957
AUDRAIN COUNTY	**4**	**15**	**$94,840**	**$6,165**
MEXICO, CITY OF	2	7	$31,593	$4,662
VANDALIA, CITY OF	2	8	$63,247	$7,668
BARRY COUNTY	**5**	**12**	**$1,351,667**	**$95,835**
MONETT, CITY OF	5	12	$1,351,667	$95,835
BARTON COUNTY	**1**	**3**	**$11,853**	**$3,951**
LAMAR, CITY OF	1	3	$11,853	$3,951
BATES COUNTY	**2**	**4**	**$80,429**	**$20,107**
BATES COUNTY *	1	2	$54,965	$27,483
BUTLER, CITY OF	1	2	$25,464	$12,732
BENTON COUNTY	**1**	**2**	**$15,530**	**$7,765**
OLD MONROE, CITY OF	1	2	$15,530	$7,765
BOLLINGER COUNTY	**13**	**27**	**$465,259**	**$17,332**
BOLLINGER COUNTY *	5	10	$184,113	$18,411
LUTESVILLE, CITY OF	2	4	$8,489	$2,122
MARBLE HILL, CITY OF	6	13	$272,657	$21,503
BOONE COUNTY	**11**	**30**	**$419,223**	**$13,260**
BOONE COUNTY *	5	15	$191,284	$12,002
COLUMBIA, CITY OF	4	11	$126,068	$8,727
HARTSBURG, VILLAGE OF	2	4	$101,871	$25,468
BUCHANAN COUNTY	**57**	**145**	**$8,353,935**	**$64,923**
AGENCY, TOWN OF	1	3	$169,427	$56,476
ANDREW COUNTY*	1	2	$68,459	$34,230
BUCHANAN COUNTY*	19	50	$1,269,439	$26,313

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
LEWIS AND CLARK, VILLAGE OF	18	49	$2,118,371	$44,778
ST. JOSEPH, CITY OF	18	41	$4,728,239	$125,852
BUTLER COUNTY	**69**	**157**	**$5,859,015**	**$36,156**
BUTLER COUNTY*	50	114	$3,906,014	$33,143
CARTER COUNTY*	1	2	$66,579	$33,289
POPLAR BLUFF, CITY OF	16	37	$1,831,392	$48,549
QULIN, CITY OF	2	4	$55,030	$13,758
CALLAWAY COUNTY	**24**	**71**	**$1,115,027**	**$17,639**
CALLAWAY COUNTY*	4	8	$237,091	$29,636
COLE COUNTY*	2	8	$96,655	$14,223
FULTON, CITY OF	4	15	$106,073	$7,406
JEFFERSON CITY, CITY OF	10	27	$521,509	$19,065
LICKING, CITY OF	1	2	$59,160	$29,580
MOKANE, CITY OF	2	7	$53,160	$8,078
ST. LOUIS COUNTY *	1	4	$41,378	$10,345
CAMDEN COUNTY	**7**	**15**	**$443,983**	**$29,647**
CAMDEN COUNTY *	6	13	$419,948	$32,586
VERNON COUNTY*	1	2	$24,035	$12,018
CAPE GIRARDEAU COUNTY	**51**	**126**	**$1,575,917**	**$13,155**
CAPE GIRARDEAU COUNTY*	15	38	$572,455	$15,687
CAPE GIRARDEAU, CITY OF	32	76	$920,031	$12,767
JACKSON, CITY OF	4	12	$83,431	$6,759
CARROLL COUNTY	**14**	**32**	**$812,199**	**$26,446**
CARROLL COUNTY*	10	22	$553,355	$24,881
CARROLLTON, TOWN OF	4	10	$258,844	$30,359
CARTER COUNTY	**8**	**21**	**$772,956**	**$36,804**
CARTER COUNTY*	4	10	$613,142	$59,643
VAN BUREN, CITY OF	4	11	$159,814	$13,965
CASS COUNTY	**37**	**94**	**$1,667,433**	**$18,174**
BELTON, CITY OF	2	4	$14,231	$3,558
CASS COUNTY *	9	22	$352,334	$16,768
FREEMAN, CITY OF	3	6	$66,682	$11,114
HARRISONVILLE, CITY OF	2	4	$73,562	$18,391
LAKE ANNETTE, CITY OF	3	8	$227,184	$27,536
LAKE WINNEBAGO, CITY OF	2	5	$217,223	$42,267
PECULIAR, CITY OF	9	26	$561,693	$24,453
PLEASANT HILL, CITY OF	5	14	$101,252	$7,403
RAYMORE, CITY OF	1	3	$39,592	$13,197
WARREN COUNTY*	1	2	$13,680	$6,840
CHARITON COUNTY	**4**	**10**	**$123,479**	**$12,373**
BRUNSWICK, CITY OF	1	3	$6,741	$2,247

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
CHARITON COUNTY*	3	7	$116,738	$15,748
CHRISTIAN COUNTY	**8**	**20**	**$721,710**	**$35,192**
CHRISTIAN COUNTY *	6	15	$404,493	$25,548
OZARK, CITY OF	2	5	$317,218	$64,127
CLARK COUNTY	**6**	**16**	**$741,042**	**$47,604**
ALEXANDRIA, CITY OF	2	4	$66,403	$16,601
CLARK COUNTY *	4	12	$674,638	$63,105
CLAY COUNTY	**56**	**146**	**$3,307,904**	**$22,136**
AVONDALE,CITY OF	2	8	$42,935	$5,446
BIRMINGHAM, VILLAGE OF	1	2	$36,460	$18,230
CLAY COUNTY *	2	4	$211,614	$52,904
CLAYCOMO, VILLAGE OF	10	35	$594,960	$19,014
EXCELSIOR SPRINGS, CITY OF	7	19	$1,355,004	$66,330
GLADSTONE, CITY OF	3	6	$78,049	$13,008
KANSAS CITY, CITY OF	13	33	$288,329	$8,267
MISSOURI CITY, CITY OF	1	2	$10,999	$5,499
MOSBY, CITY OF	6	15	$376,912	$23,656
NORTH KANSAS CITY, CITY OF	1	2	$28,330	$14,165
PLATTE COUNTY*	1	2	$34,022	$17,011
RAY COUNTY *	1	2	$42,236	$21,118
SMITHVILLE, CITY OF	8	16	$208,053	$13,003
CLINTON COUNTY	**1**	**3**	**$25,621**	**$8,540**
ALEXANDRIA, CITY OF	1	3	$25,621	$8,540
COLE COUNTY	**32**	**84**	**$1,686,367**	**$20,745**
COLE COUNTY*	19	51	$787,818	$16,091
JEFFERSON CITY, CITY OF	11	29	$815,076	$28,763
JEFFERSON COUNTY*	1	2	$27,073	$13,537
TAOS, CITY OF	1	2	$56,400	$28,200
CRAWFORD COUNTY	**12**	**31**	**$1,818,300**	**$70,300**
CRAWFORD COUNTY*	9	22	$1,764,686	$91,763
STEELVILLE, CITY OF	3	9	$53,614	$5,911
DAVIESS COUNTY	**1**	**2**	**$15,284**	**$7,642**
PATTONSBURG, CITY OF	1	2	$15,284	$7,642
DUNKLIN COUNTY	**4**	**8**	**$100,876**	**$12,609**
CARDWELL, CITY OF	1	2	$3,686	$1,843
DUNKLIN COUNTY *	2	4	$93,587	$23,397
KENNETT, CITY OF	1	2	$3,602	$1,801
FRANKLIN COUNTY	**136**	**339**	**$11,256,717**	**$36,260**
BERGER, CITY OF	1	2	$13,780	$6,890
EUREKA, CITY OF	2	5	$148,454	$26,496
FRANKLIN COUNTY *	52	129	$3,125,250	$25,704

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
FRANKLIN, CITY OF	1	4	$27,390	$6,847
GASCONADE COUNTY*	2	9	$54,592	$8,855
PACIFIC, CITY OF	70	172	$6,450,651	$40,013
ST. CLAIR,CITY OF	1	2	$20,955	$10,478
ST. LOUIS COUNTY *	1	3	$25,790	$8,597
UNION, CITY OF	5	11	$1,386,635	$137,751
WASHINGTON, CITY OF	1	2	$3,220	$1,610
GASCONADE COUNTY	**35**	**93**	**$3,284,420**	**$32,326**
FRANKLIN COUNTY *	1	3	$42,516	$14,172
GASCONADE COUNTY*	20	54	$1,067,791	$22,185
GASCONADE, CITY OF	4	9	$248,031	$28,055
HERMANN, CITY OF	8	23	$1,883,823	$67,525
MORRISON, CITY OF	1	2	$3,795	$1,897
OSAGE COUNTY*	1	2	$38,465	$19,232
GENTRY COUNTY	**1**	**2**	**$35,554**	**$17,777**
ALBANY, CITY OF	1	2	$35,554	$17,777
GREENE COUNTY	**16**	**39**	**$967,905**	**$27,537**
GREENE COUNTY *	4	12	$101,558	$9,040
REPUBLIC, CITY OF	1	3	$9,563	$3,188
SPRINGFIELD, CITY OF	11	24	$856,783	$36,476
HARRISON COUNTY	**1**	**3**	**$95,647**	**$31,882**
BIG LAKE, VILLAGE OF	1	3	$95,647	$31,882
HOLT COUNTY	**102**	**275**	**$7,270,637**	**$27,326**
BIG LAKE, VILLAGE OF	78	216	$5,314,670	$24,819
BIGELOW, VILLAGE OF	1	3	$103,041	$34,347
CORNING, TOWN OF	1	2	$158,767	$79,384
CRAIG, CITY OF	1	2	$63,649	$31,824
FORTESCUE, TOWN OF	3	7	$92,394	$14,143
HOLT COUNTY*	17	43	$1,527,891	$38,722
MOUND CITY, CITY OF	1	2	$10,225	$5,113
HOWARD COUNTY	**4**	**13**	**$130,289**	**$11,713**
FRANKLIN COUNTY *	1	2	$36,260	$18,130
FRANKLIN, CITY OF	1	5	$19,650	$3,930
HOWARD COUNTY*	1	3	$69,267	$23,089
NEW FRANKLIN, TOWN OF	1	3	$5,113	$1,704
HOWELL COUNTY	**2**	**4**	**$77,799**	**$19,450**
WEST PLAINS, CITY OF	2	4	$77,799	$19,450
IRON COUNTY	**3**	**7**	**$24,986**	**$3,414**
IRONTON, CITY OF	3	7	$24,986	$3,414
JACKSON COUNTY	**157**	**396**	**$13,653,439**	**$35,720**
BLUE SPRINGS, CITY OF	3	7	$69,371	$10,967

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
BUCKNER, CITY OF	2	8	$89,616	$12,696
GRANDVIEW, CITY OF	4	11	$414,755	$45,713
INDEPENDENCE,CITY OF	17	40	$573,164	$14,615
JACKSON COUNTY *	1	2	$44,155	$22,077
KANSAS CITY, CITY OF	104	264	$11,750,745	$46,570
LAKE LOTAWANA, CITY OF	1	2	$29,389	$14,694
LEE'S SUMMIT, CITY OF	6	16	$355,052	$15,492
LEVASY, CITY OF	2	5	$70,914	$16,757
OAK GROVE, CITY OF	1	2	$3,680	$1,840
PLATTE COUNTY*	1	2	$6,159	$3,079
RAYTOWN, CITY OF	14	33	$234,192	$7,423
SUGAR CREEK, CITY OF	1	4	$12,247	$3,062
JASPER COUNTY	**17**	**37**	**$806,506**	**$21,915**
CARTHAGE, CITY OF	3	7	$90,389	$12,287
JASPER COUNTY*	8	18	$530,053	$30,334
JOPLIN, CITY OF	5	10	$177,041	$17,704
SARCOXIE, CITY OF	1	2	$9,024	$4,512
JEFFERSON COUNTY	**238**	**691**	**$12,489,875**	**$19,642**
ARNOLD, CITY OF	22	65	$954,298	$14,123
CRYSTAL CITY,CITY OF	17	57	$1,128,206	$25,392
DE SOTO, CITY OF	9	18	$492,046	$27,336
EUREKA, CITY OF	1	3	$48,906	$16,302
FENTON, CITY OF	2	4	$39,293	$9,823
FESTUS,CITY OF	9	22	$418,356	$18,476
FRANKLIN COUNTY *	1	2	$12,021	$6,011
HERCULANEUM, CITY OF	1	2	$43,527	$21,764
JEFFERSON COUNTY*	168	498	$9,126,995	$19,975
MOLINE ACRES, CITY OF	1	4	$20,464	$5,116
ST. LOUIS COUNTY *	5	11	$148,958	$14,144
ST. LOUIS, CITY OF	1	3	$22,317	$7,439
VALLEY PARK, CITY OF	1	2	$34,488	$17,244
JOHNSON COUNTY	**4**	**9**	**$106,845**	**$10,596**
JOHNSON COUNTY *	1	2	$4,384	$2,192
KNOB NOSTER, CITY OF	1	2	$23,051	$11,525
LEETON, CITY OF	1	3	$66,233	$22,078
WARRENSBURG, CITY OF	1	2	$13,177	$6,588
LACLEDE COUNTY	**3**	**7**	**$361,574**	**$42,022**
LACLEDE COUNTY *	1	3	$328,332	$109,444
LEBANON, CITY OF	2	4	$33,242	$8,311
LAFAYETTE COUNTY	**2**	**4**	**$77,701**	**$19,425**
LAFAYETTE COUNTY *	2	4	$77,701	$19,425

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
LAWRENCE COUNTY	**1**	**2**	**$99,018**	**$49,509**
PIERCE CITY, CITY OF	1	2	$99,018	$49,509
LEWIS COUNTY	**14**	**44**	**$756,874**	**$17,130**
CANTON, CITY OF	3	9	$83,379	$9,264
LAGRANGE,CITY OF	11	35	$673,495	$19,275
LINCOLN COUNTY	**132**	**468**	**$5,503,873**	**$13,975**
ELSBERRY, CITY OF	3	14	$82,236	$5,649
FLORISSANT, CITY OF	1	2	$32,422	$16,211
FOLEY, CITY OF	7	17	$235,483	$13,105
LINCOLN COUNTY *	85	340	$3,891,902	$14,329
OLD MONROE, CITY OF	10	28	$229,309	$7,631
PIKE COUNTY *	8	28	$287,466	$11,444
SILEX, VILLAGE OF	3	7	$210,984	$30,775
TROY, CITY OF	2	5	$93,528	$16,192
WINFIELD, CITY OF	13	27	$440,545	$16,092
LINN COUNTY	**4**	**11**	**$99,688**	**$9,142**
BROOKFIELD, CITY OF	4	11	$99,688	$9,142
LIVINGSTON COUNTY	**1**	**2**	**$41,139**	**$20,569**
CHILLICOTHE, CITY OF	1	2	$41,139	$20,569
MADISON COUNTY	**16**	**36**	**$507,990**	**$14,364**
FREDERICKTOWN, CITY OF	14	32	$395,825	$12,411
MADISON COUNTY *	1	2	$71,137	$35,569
MARQUAND, CITY OF	1	2	$41,028	$20,514
MARIES COUNTY	**16**	**45**	**$1,272,610**	**$28,493**
MARIES COUNTY*	16	45	$1,272,610	$28,493
MARION COUNTY	**22**	**51**	**$1,908,457**	**$33,867**
HANNIBAL, CITY OF	9	20	$1,250,598	$53,417
MARION COUNTY *	12	26	$465,721	$18,825
RALLS COUNTY *	1	5	$192,139	$38,428
MCDONALD COUNTY	**26**	**63**	**$3,477,061**	**$58,398**
ANDERSON, CITY OF	1	2	$113,733	$56,867
MCDONALD COUNTY *	15	32	$1,992,233	$62,472
NOEL, CITY OF	8	24	$961,515	$42,446
PINEVILLE, CITY OF	1	3	$119,817	$39,939
SOUTHWEST CITY, CITY OF	1	2	$289,763	$144,881
MILLER COUNTY	**2**	**4**	**$216,278**	**$54,070**
MILLER COUNTY*	1	2	$204,574	$102,287
TUSCUMBIA, VILLAGE OF	1	2	$11,704	$5,852
MISSISSIPPI COUNTY	**8**	**19**	**$126,289**	**$6,457**
EAST PRAIRIE, CITY OF	1	3	$4,308	$1,436
MISSISSIPPI COUNTY *	5	11	$102,475	$8,606

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
NEW MADRID COUNTY *	2	5	$19,506	$3,596
MONROE COUNTY	**1**	**3**	**$11,680**	**$3,893**
PARIS, CITY OF	1	3	$11,680	$3,893
MONTGOMERY COUNTY	**4**	**9**	**$242,553**	**$29,273**
MONTGOMERY COUNTY*	1	2	$42,084	$21,042
RHINELAND, TOWN OF	2	5	$35,102	$6,684
WARRENTON, CITY OF	1	2	$165,367	$82,684
NEW MADRID COUNTY	**24**	**54**	**$1,253,988**	**$23,437**
LILBOURN, CITY OF	11	24	$645,588	$27,447
NEW MADRID COUNTY *	4	8	$217,693	$27,212
NEW MADRID, CITY OF	8	20	$372,506	$17,829
RISCO, CITY OF	1	2	$18,200	$9,100
NEWTON COUNTY	**23**	**52**	**$1,855,788**	**$36,521**
GRANBY, CITY OF	1	3	$90,952	$30,317
JOPLIN, CITY OF	1	2	$99,389	$49,695
NEOSHO, CITY OF	6	12	$667,119	$55,593
NEWTON COUNTY *	9	23	$778,623	$35,173
SAGINAW, VILLAGE OF	3	6	$135,522	$22,587
SENECA, CITY OF	3	6	$84,182	$14,030
OREGON COUNTY	**1**	**3**	**$18,205**	**$6,068**
ST. CHARLES COUNTY *	1	3	$18,205	$6,068
OSAGE COUNTY	**18**	**46**	**$950,900**	**$19,318**
CHAMOIS, CITY OF	3	7	$68,966	$10,131
OSAGE COUNTY*	15	39	$881,933	$21,155
OZARK COUNTY	**1**	**2**	**$103,584**	**$51,792**
GAINESVILLE, CITY OF	1	2	$103,584	$51,792
PEMISCOT COUNTY	**8**	**18**	**$235,771**	**$13,657**
CARUTHERSVILLE, CITY OF	5	11	$120,038	$11,526
PEMISCOT COUNTY *	2	5	$101,170	$22,170
STEELE, CITY OF	1	2	$14,563	$7,281
PERRY COUNTY	**4**	**9**	**$311,587**	**$36,072**
PERRY COUNTY*	4	9	$311,587	$36,072
PETTIS COUNTY	**4**	**9**	**$60,025**	**$6,957**
PETTIS COUNTY *	1	2	$38,075	$19,038
SEDALIA, CITY OF	3	7	$21,950	$2,930
PHELPS COUNTY	**34**	**90**	**$3,265,191**	**$37,442**
MARIES COUNTY*	4	10	$244,988	$23,097
NEWBURG, CITY OF	1	2	$88,764	$44,382
PHELPS COUNTY*	17	44	$1,786,961	$42,877
PULASKI COUNTY *	4	10	$318,814	$32,878
ROLLA, CITY OF	8	24	$825,665	$34,481

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
PIKE COUNTY	**60**	**235**	**$2,137,922**	**$10,428**
ANNADA, VILLAGE OF	3	7	$40,985	$5,423
CLARKSVILLE, CITY OF	12	52	$549,178	$15,112
LOUISIANA, CITY OF	10	33	$324,679	$10,210
PIKE COUNTY *	35	143	$1,223,080	$9,313
PLATTE COUNTY	**21**	**51**	**$1,335,526**	**$29,202**
KANSAS CITY, CITY OF	4	12	$111,139	$9,237
PARKVILLE, CITY OF	1	2	$5,479	$2,740
PLATTE CITY, CITY OF	1	3	$37,786	$12,595
PLATTE COUNTY*	12	28	$830,376	$32,132
RIVERSIDE, CITY OF	3	6	$350,745	$58,458
PULASKI COUNTY	**25**	**56**	**$1,669,566**	**$29,592**
PHELPS COUNTY*	1	3	$38,128	$12,709
PULASKI COUNTY *	15	32	$1,119,505	$34,310
WAYNESVILLE, CITY OF	9	21	$511,933	$23,604
RALLS COUNTY	**7**	**16**	**$338,578**	**$21,856**
MARION COUNTY *	1	2	$33,364	$16,682
RALLS COUNTY *	6	14	$305,213	$22,719
RAY COUNTY	**4**	**9**	**$131,761**	**$14,533**
ORRICK, CITY OF	2	5	$99,653	$21,038
RAY COUNTY *	2	4	$32,109	$8,027
REYNOLDS COUNTY	**8**	**20**	**$232,690**	**$11,071**
ELLINGTON, CITY OF	3	7	$90,777	$11,280
REYNOLDS COUNTY*	5	13	$141,913	$10,945
RIPLEY COUNTY	**32**	**79**	**$4,430,129**	**$56,153**
DONIPHAN, CITY OF	6	18	$1,177,874	$64,813
RIPLEY COUNTY*	26	61	$3,252,254	$54,155
SALINE COUNTY	**1**	**2**	**$25,361**	**$12,681**
SALINE COUNTY *	1	2	$25,361	$12,681
SCOTT COUNTY	**35**	**89**	**$1,289,887**	**$13,753**
COMMERCE, CITY OF	6	15	$176,249	$11,028
MINER, CITY OF	1	2	$33,979	$16,989
SCOTT CITY, CITY OF	4	10	$120,300	$11,362
SCOTT COUNTY*	19	50	$808,441	$15,773
SIKESTON, CITY OF	5	12	$150,918	$10,610
SHANNON COUNTY	**4**	**9**	**$108,698**	**$11,112**
EMINENCE, CITY OF	3	7	$102,405	$13,767
WINONA, CITY OF	1	2	$6,293	$3,147
SHELBY COUNTY	**1**	**2**	**$50,573**	**$25,287**
MARION COUNTY *	1	2	$50,573	$25,287
ST. CHARLES COUNTY	**337**	**1094**	**$22,286,332**	**$22,110**

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
ALTON, CITY OF	2	5	$61,624	$11,025
CHESTERFIELD, CITY OF	1	3	$64,978	$21,659
LINCOLN COUNTY *	1	3	$25,081	$8,360
MARCELINE, CITY OF	1	2	$3,205	$1,602
O'FALLON, CITY OF	2	4	$113,051	$28,263
OLD MONROE, CITY OF	1	2	$10,080	$5,040
PORTAGE DES SIOUX, CITY OF	21	69	$785,020	$12,456
ST. CHARLES COUNTY *	229	762	$14,143,554	$20,505
ST. CHARLES, CITY OF	38	116	$3,164,766	$27,595
ST. PETERS, CITY OF	1	4	$22,702	$5,675
WELLSTON, CITY OF	1	2	$26,235	$13,118
WEST ALTON, TOWN OF	39	122	$3,866,036	$33,624
ST. FRANCOIS COUNTY	**6**	**15**	**$459,812**	**$32,313**
ELVINS, CITY OF	1	2	$28,294	$14,147
PARK HILLS, CITY OF	1	2	$54,923	$27,461
ST. FRANCOIS COUNTY*	4	11	$376,596	$38,068
ST. LOUIS CITY	**33**	**92**	**$2,007,429**	**$24,032**
ARNOLD, CITY OF	4	8	$76,432	$9,554
ELSBERRY, CITY OF	1	2	$38,382	$19,191
FRANKLIN COUNTY *	1	2	$16,823	$8,412
JEFFERSON COUNTY*	2	9	$107,940	$10,818
LINCOLN COUNTY *	2	4	$43,805	$10,951
PORTAGE DES SIOUX, CITY OF	1	3	$11,509	$3,836
ST. CHARLES COUNTY *	3	9	$35,963	$3,875
ST. CHARLES, CITY OF	1	7	$45,346	$6,478
ST. LOUIS COUNTY *	5	12	$196,356	$17,815
ST. LOUIS, CITY OF	13	36	$1,434,873	$44,053
ST. LOUIS COUNTY	**538**	**1452**	**$48,280,934**	**$36,391**
ARNOLD, CITY OF	2	8	$42,045	$5,256
BALLWIN, CITY OF	3	6	$355,291	$59,215
BELLEFONTAINE NEIGHBORS, CITY OF	1	3	$42,527	$14,176
BERKELEY, CITY OF	1	2	$18,975	$9,488
BONNE TERRE, CITY OF	1	7	$34,483	$4,926
BRECKENRIDGE HILLS, CITY OF	21	56	$830,746	$14,762
BRENTWOOD, CITY OF	15	39	$3,398,436	$92,763
BRIDGETON, CITY OF	4	9	$135,629	$14,874
CHESTERFIELD, CITY OF	2	4	$896,408	$224,102
COOL VALLEY, CITY OF	1	2	$7,903	$3,952
CRESTWOOD, CITY OF	3	8	$143,098	$16,171
DES PERES, CITY OF	1	2	$21,039	$10,520

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
EUREKA, CITY OF	11	27	$1,870,647	$66,643
FENTON, CITY OF	27	72	$4,388,351	$72,959
FERGUSON, CITY OF	30	70	$241,652	$3,381
FLORISSANT, CITY OF	19	45	$636,950	$15,168
FRANKLIN COUNTY *	1	2	$43,514	$21,757
FRONTENAC, CITY OF	4	11	$65,650	$6,165
HANLEY HILLS, VILLAGE OF	1	2	$4,708	$2,354
HAZELWOOD, CITY OF	33	108	$5,737,092	$57,696
JEFFERSON CITY, CITY OF	1	2	$11,381	$5,691
JEFFERSON COUNTY*	6	16	$206,136	$12,717
JENNINGS, CITY OF	3	6	$40,004	$6,667
KIRKWOOD, CITY OF	8	16	$316,811	$30,955
LADUE,CITY OF	12	41	$1,568,187	$33,137
LINCOLN COUNTY *	5	14	$75,785	$5,532
MACKENZIE, VILLAGE OF	1	2	$8,815	$4,407
MANCHESTER, CITY OF	5	16	$386,053	$24,484
MAPLEWOOD, CITY OF	7	24	$91,941	$3,766
MARYLAND HEIGHTS, CITY OF	2	5	$301,088	$50,604
MOLINE ACRES, CITY OF	3	6	$36,125	$6,021
NORTHWOODS, CITY OF	11	27	$254,080	$8,876
OAKLAND, CITY OF	1	2	$3,583	$1,791
OLIVETTE, CITY OF	1	5	$21,533	$4,307
OVERLAND, CITY OF	7	18	$54,387	$2,934
PACIFIC, CITY OF	2	4	$171,729	$42,932
PORTAGE DES SIOUX, CITY OF	1	6	$55,088	$9,181
ROCK HILL, CITY OF	4	9	$152,464	$18,147
SCOTT COUNTY*	1	2	$22,670	$11,335
ST. ANN, CITY OF	5	11	$42,562	$3,628
ST. CHARLES COUNTY *	35	100	$860,744	$9,413
ST. CHARLES, CITY OF	1	5	$34,828	$6,966
ST. JOHN, CITY OF	2	4	$8,887	$2,222
ST. LOUIS COUNTY *	135	362	$14,918,758	$44,026
ST. LOUIS, CITY OF	3	6	$238,634	$39,772
SUNSET HILLS, CITY OF	15	33	$6,173,103	$201,891
UNIVERSITY CITY, CITY OF	52	149	$1,109,530	$7,640
VALLEY PARK, CITY OF	21	61	$1,957,156	$35,837
VELDA VILLAGE HILLS, VILLAGE OF	1	2	$4,283	$2,141
WEBSTER GROVES, CITY OF	3	8	$76,743	$10,447
WELLSTON, CITY OF	1	2	$25,376	$12,688
WILDWOOD, CITY OF	1	3	$129,480	$43,160

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
WINDSOR, CITY OF	1	2	$7,847	$3,923
STE. GENEVIEVE COUNTY	**62**	**187**	**$1,403,705**	**$8,250**
ST. MARY, CITY OF	1	2	$61,140	$30,570
STE. GENEVIEVE COUNTY*	2	5	$61,689	$13,651
STE. GENEVIEVE, CITY OF	59	180	$1,280,876	$7,688
STODDARD COUNTY	**12**	**27**	**$451,151**	**$16,837**
ADVANCE, CITY OF	1	2	$29,265	$14,632
BLOOMFIELD, CITY OF	1	2	$26,320	$13,160
BOLLINGER COUNTY *	1	2	$19,952	$9,976
STODDARD COUNTY*	9	21	$375,613	$18,252
STONE COUNTY	**13**	**28**	**$717,470**	**$26,173**
GALENA, CITY OF	4	8	$306,272	$38,284
REEDS SPRING, CITY OF	2	4	$67,090	$16,772
STONE COUNTY*	7	16	$344,108	$21,938
TANEY COUNTY	**52**	**119**	**$5,850,918**	**$49,025**
BRANSON, CITY OF	10	24	$619,797	$26,333
BULL CREEK, VILLAGE OF	5	10	$172,920	$17,292
HOLLISTER, CITY OF	1	2	$9,236	$4,618
ROCKAWAY BEACH, CITY OF	3	6	$70,278	$11,713
TANEY COUNTY*	33	77	$4,978,687	$65,446
TEXAS COUNTY	**1**	**2**	**$56,870**	**$28,435**
HOUSTON, CITY OF	1	2	$56,870	$28,435
VERNON COUNTY	**1**	**2**	**$24,212**	**$12,106**
VERNON COUNTY*	1	2	$24,212	$12,106
WARREN COUNTY	**10**	**22**	**$1,433,393**	**$69,513**
MARTHASVILLE, CITY OF	3	7	$175,945	$24,214
WARREN COUNTY*	6	13	$250,756	$19,856
WARRENTON, CITY OF	1	2	$1,006,692	$503,346
WASHINGTON COUNTY	**3**	**9**	**$67,752**	**$9,659**
MINERAL POINT, VILLAGE OF	1	2	$15,338	$7,669
POTOSI, CITY OF	1	2	$36,082	$18,041
ST. CHARLES COUNTY *	1	5	$16,332	$3,266
WAYNE COUNTY	**8**	**16**	**$581,312**	**$36,332**
BUTLER COUNTY*	1	2	$88,567	$44,283
PIEDMONT, CITY OF	3	6	$415,684	$69,281
WAYNE COUNTY*	4	8	$77,061	$9,633
WRIGHT COUNTY	**1**	**2**	**$70,599**	**$35,300**
MOUNTAIN GROVE, CITY OF	1	2	$70,599	$35,300
Grand Total	**2818**	**7741**	**$201,938,095**	**$28,543**

*Average payment is calculated as the mean of all properties' average payments within each community.

Source: SEMA, PIVOT

Repetitive Loss Data – MITIGATED

Table A.48 presents the number of mitigated repetitive loss properties by county along with the number of NFIP claims, paid losses, and average payment amount.

Table A.48. Missouri Mitigated Repetitive Loss County Summary

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
ATCHISON COUNTY	**1**	**2**	**$11,382**	**$5,691**
TARKIO, CITY OF	1	2	$11,382	$5,691
BENTON COUNTY	**3**	**8**	**$82,066**	**$10,174**
LINCOLN COUNTY *	2	5	$57,853	$11,225
WINFIELD, CITY OF	1	3	$24,212	$8,071
BOLLINGER COUNTY	**5**	**10**	**$211,852**	**$21,185**
LUTESVILLE, CITY OF	2	4	$25,045	$6,261
MARBLE HILL, CITY OF	3	6	$186,807	$31,135
BOONE COUNTY	**1**	**5**	**$33,386**	**$6,677**
COLUMBIA, CITY OF	1	5	$33,386	$6,677
BUCHANAN COUNTY	**13**	**33**	**$1,303,840**	**$38,231**
BUCHANAN COUNTY*	2	4	$92,602	$23,150
LEWIS AND CLARK, VILLAGE OF	2	6	$471,192	$78,532
PLATTE COUNTY*	6	15	$554,640	$35,780
RUSHVILLE, CITY OF	1	2	$104,409	$52,204
ST. JOSEPH, CITY OF	2	6	$80,998	$13,378
CALLAWAY COUNTY	**19**	**46**	**$605,464**	**$13,697**
CALLAWAY COUNTY*	3	6	$72,853	$12,142
JEFFERSON CITY, CITY OF	14	36	$506,600	$15,058
MOKANE, CITY OF	2	4	$26,011	$6,503
CAMDEN COUNTY	**2**	**4**	**$63,664**	**$15,916**
CAMDEN COUNTY *	2	4	$63,664	$15,916
CAPE GIRARDEAU COUNTY	**57**	**201**	**$1,401,411**	**$7,486**
CAPE GIRARDEAU COUNTY*	6	20	$256,176	$13,149
CAPE GIRARDEAU, CITY OF	51	181	$1,145,235	$6,820
CARROLL COUNTY	**4**	**8**	**$171,124**	**$21,391**
CARROLL COUNTY*	1	2	$10,129	$5,064
CARROLLTON, TOWN OF	3	6	$160,995	$26,833
CASS COUNTY	**4**	**12**	**$86,259**	**$7,124**
FREEMAN, CITY OF	1	2	$16,745	$8,373
PLEASANT HILL, CITY OF	3	10	$69,513	$6,708
CHARITON COUNTY	**2**	**4**	**$45,674**	**$11,419**
BRUNSWICK, CITY OF	2	4	$45,674	$11,419
CLARK COUNTY	**1**	**2**	**$22,696**	**$11,348**
CAPE GIRARDEAU COUNTY*	1	2	$22,696	$11,348

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
CLAY COUNTY	**9**	**24**	**$332,882**	**$12,985**
AVONDALE,CITY OF	3	9	$88,754	$9,598
CLAY COUNTY *	1	3	$96,752	$32,251
EXCELSIOR SPRINGS, CITY OF	2	6	$107,225	$17,871
KANSAS CITY, CITY OF	1	2	$14,221	$7,111
SMITHVILLE, CITY OF	2	4	$25,930	$6,482
COLE COUNTY	**11**	**28**	**$398,183**	**$14,625**
JEFFERSON CITY, CITY OF	11	28	$398,183	$14,625
DAVIESS COUNTY	**10**	**20**	**$309,270**	**$15,463**
PATTONSBURG, CITY OF	10	20	$309,270	$15,463
DEKALB COUNTY	**2**	**5**	**$83,936**	**$14,844**
BIG LAKE, VILLAGE OF	1	3	$73,676	$24,559
PATTONSBURG, CITY OF	1	2	$10,260	$5,130
FRANKLIN COUNTY	**21**	**57**	**$600,707**	**$11,237**
FRANKLIN COUNTY *	10	27	$214,709	$7,617
JEFFERSON COUNTY*	3	10	$71,900	$6,592
PACIFIC, CITY OF	4	8	$162,937	$20,367
ST. CLAIR,CITY OF	1	4	$13,113	$3,278
ST. LOUIS COUNTY *	1	4	$55,000	$13,750
WARREN COUNTY*	1	2	$53,900	$26,950
WASHINGTON, CITY OF	1	2	$29,149	$14,574
GASCONADE COUNTY	**12**	**27**	**$373,011**	**$14,665**
GASCONADE COUNTY*	1	2	$101,568	$50,784
GASCONADE, CITY OF	1	2	$59,568	$29,784
HERMANN, CITY OF	9	21	$191,875	$9,490
MONTGOMERY COUNTY*	1	2	$20,000	$10,000
GREENE COUNTY	**3**	**10**	**$94,716**	**$12,246**
GREENE COUNTY *	2	8	$89,217	$16,995
SPRINGFIELD, CITY OF	1	2	$5,499	$2,749
HOLT COUNTY	**56**	**158**	**$5,544,951**	**$36,177**
BIG LAKE, VILLAGE OF	53	149	$5,230,724	$36,079
BIGELOW, VILLAGE OF	1	2	$107,546	$53,773
CRAIG, CITY OF	1	3	$99,134	$33,045
HOLT COUNTY*	1	4	$107,548	$26,887
HOWARD COUNTY	**4**	**8**	**$49,558**	**$6,195**
FRANKLIN COUNTY *	1	2	$16,321	$8,160
FRANKLIN, CITY OF	3	6	$33,238	$5,540
IRON COUNTY	**1**	**2**	**$8,940**	**$4,470**
IRONTON, CITY OF	1	2	$8,940	$4,470
JACKSON COUNTY	**35**	**97**	**$2,084,307**	**$25,328**
INDEPENDENCE,CITY OF	9	27	$259,845	$10,243

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
JACKSON COUNTY *	1	3	$47,739	$15,913
KANSAS CITY, CITY OF	24	65	$1,765,634	$32,202
LEVASY, CITY OF	1	2	$11,090	$5,545
JEFFERSON COUNTY	**210**	**636**	**$8,243,584**	**$13,395**
ARNOLD, CITY OF	115	352	$5,245,377	$15,617
CRYSTAL CITY,CITY OF	16	53	$471,997	$10,167
FENTON, CITY OF	2	6	$49,001	$7,807
FESTUS,CITY OF	5	12	$254,868	$24,187
FRANKLIN COUNTY *	1	3	$21,572	$7,191
HERCULANEUM, CITY OF	2	4	$13,131	$3,283
JEFFERSON COUNTY*	64	194	$2,055,681	$10,049
ST. LOUIS COUNTY *	3	6	$100,091	$16,682
TIMES BEACH, CITY OF	2	6	$31,866	$5,400
LAFAYETTE COUNTY	**1**	**3**	**$56,152**	**$18,717**
LAFAYETTE COUNTY *	1	3	$56,152	$18,717
LEWIS COUNTY	**2**	**6**	**$134,460**	**$19,886**
LAGRANGE,CITY OF	2	6	$134,460	$19,886
LINCOLN COUNTY	**92**	**257**	**$3,491,902**	**$14,350**
ELSBERRY, CITY OF	1	3	$4,369	$1,456
FOLEY, CITY OF	5	11	$102,182	$9,579
LINCOLN COUNTY *	81	231	$3,146,251	$14,377
OLD MONROE, CITY OF	3	8	$101,985	$12,582
WINFIELD, CITY OF	2	4	$137,115	$34,279
MADISON COUNTY	**6**	**13**	**$88,988**	**$6,712**
FREDERICKTOWN, CITY OF	6	13	$88,988	$6,712
MARION COUNTY	**23**	**57**	**$1,300,047**	**$22,059**
HANNIBAL, CITY OF	20	48	$1,163,973	$22,376
MARION COUNTY *	2	7	$87,836	$17,859
MT. VERNON, CITY OF	1	2	$48,239	$24,119
MCDONALD COUNTY	**1**	**3**	**$134,431**	**$44,810**
ANDERSON, CITY OF	1	3	$134,431	$44,810
MONTGOMERY COUNTY	**26**	**60**	**$672,852**	**$10,655**
MONTGOMERY COUNTY*	14	31	$264,371	$8,219
RHINELAND, TOWN OF	12	29	$408,481	$13,496
NEWTON COUNTY	**1**	**3**	**$95,955**	**$31,985**
NEWTON COUNTY *	1	3	$95,955	$31,985
OREGON COUNTY	**1**	**3**	**$23,566**	**$7,855**
ST. CHARLES COUNTY *	1	3	$23,566	$7,855
OSAGE COUNTY	**2**	**4**	**$208,034**	**$52,009**
OSAGE COUNTY*	2	4	$208,034	$52,009
PERRY COUNTY	**1**	**3**	**$32,588**	**$10,863**

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
ST. MARY, CITY OF	1	3	$32,588	$10,863
PHELPS COUNTY	**3**	**8**	**$296,206**	**$33,929**
MARIES COUNTY*	1	2	$18,310	$9,155
PHELPS COUNTY*	2	6	$277,896	$46,316
PIKE COUNTY	**8**	**21**	**$513,773**	**$24,814**
CLARKSVILLE, CITY OF	2	5	$163,056	$30,932
LINCOLN COUNTY *	1	3	$52,612	$17,537
PIKE COUNTY *	5	13	$298,104	$23,823
PLATTE COUNTY	**14**	**28**	**$647,863**	**$23,138**
EDGERTON, CITY OF	3	6	$53,795	$8,966
KANSAS CITY, CITY OF	2	4	$42,126	$10,531
PLATTE CITY, CITY OF	1	2	$40,768	$20,384
PLATTE COUNTY*	6	12	$488,140	$40,678
TRACY, CITY OF	2	4	$23,034	$5,759
PULASKI COUNTY	**2**	**6**	**$145,413**	**$19,616**
PULASKI COUNTY *	1	4	$133,898	$33,475
WAYNESVILLE, CITY OF	1	2	$11,514	$5,757
RAY COUNTY	**4**	**8**	**$134,175**	**$16,772**
HARDIN, CITY OF	3	6	$73,844	$12,307
ORRICK, CITY OF	1	2	$60,331	$30,165
SCOTT COUNTY	**20**	**51**	**$432,037**	**$8,223**
COMMERCE, CITY OF	19	49	$425,019	$8,472
ILLMO, CITY OF	1	2	$7,019	$3,509
ST. CHARLES COUNTY	**621**	**1939**	**$23,372,424**	**$12,901**
ALTON, CITY OF	2	5	$120,294	$24,455
FLORISSANT, CITY OF	2	6	$96,220	$16,037
LINCOLN COUNTY *	2	4	$67,274	$16,818
O'FALLON, CITY OF	2	6	$75,385	$12,564
PORTAGE DES SIOUX, CITY OF	25	79	$734,905	$10,592
ST. CHARLES COUNTY *	563	1763	$21,145,530	$12,817
ST. CHARLES, CITY OF	21	62	$950,772	$16,331
ST. LOUIS COUNTY *	1	3	$22,542	$7,514
ST. PETERS, CITY OF	2	7	$41,510	$5,695
WEST ALTON, TOWN OF	1	4	$117,992	$29,498
ST. LOUIS CITY	**8**	**26**	**$247,056**	**$8,840**
ST. CHARLES COUNTY *	3	9	$80,412	$9,710
ST. LOUIS COUNTY *	3	13	$143,140	$9,947
ST. LOUIS, CITY OF	2	4	$23,504	$5,876
ST. LOUIS COUNTY	**554**	**1704**	**$22,008,927**	**$13,645**
BERKELEY, CITY OF	1	3	$16,965	$5,655
BRECKENRIDGE HILLS, CITY OF	4	10	$34,224	$3,532

County and Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
BRENTWOOD, CITY OF	7	22	$337,098	$17,877
CREVE COEUR, CITY OF	1	3	$26,933	$8,978
EUREKA, CITY OF	55	174	$784,959	$4,647
FENTON, CITY OF	33	85	$988,508	$12,223
FLORISSANT, CITY OF	1	4	$54,391	$13,598
HAZELWOOD, CITY OF	1	3	$101,331	$33,777
JEFFERSON COUNTY*	10	30	$230,011	$7,786
KIRKWOOD, CITY OF	7	16	$193,919	$12,802
LINCOLN COUNTY *	1	2	$28,232	$14,116
MANCHESTER, CITY OF	1	3	$51,225	$17,075
MAPLEWOOD, CITY OF	6	19	$139,405	$7,542
MOLINE ACRES, CITY OF	1	4	$53,176	$13,294
PERRY COUNTY*	1	2	$30,906	$15,453
ST. CHARLES COUNTY *	10	37	$198,494	$5,859
ST. LOUIS COUNTY *	142	423	$6,314,796	$16,322
ST. LOUIS, CITY OF	5	19	$208,916	$11,399
UNIVERSITY CITY, CITY OF	10	44	$306,406	$6,773
VALLEY PARK, CITY OF	255	794	$11,877,917	$15,359
WELLSTON, CITY OF	1	2	$8,950	$4,475
WINONA, CITY OF	1	5	$22,165	$4,433
STE. GENEVIEVE COUNTY	**52**	**166**	**$1,008,916**	**$6,428**
ST. MARY, CITY OF	13	38	$238,449	$6,854
STE. GENEVIEVE COUNTY*	1	3	$14,753	$4,918
STE. GENEVIEVE, CITY OF	38	125	$755,713	$6,322
TANEY COUNTY	**5**	**15**	**$461,565**	**$30,783**
BRANSON, CITY OF	3	9	$326,027	$36,244
HOLLISTER, CITY OF	2	6	$135,539	$22,590
VERNON COUNTY	**1**	**2**	**$7,867**	**$3,934**
VERNON COUNTY*	1	2	$7,867	$3,934
WARREN COUNTY	**1**	**2**	**$49,367**	**$24,683**
WARREN COUNTY*	1	2	$49,367	$24,683
WASHINGTON COUNTY	**1**	**5**	**$34,653**	**$6,931**
ST. CHARLES COUNTY *	1	5	$34,653	$6,931
WAYNE COUNTY	**1**	**2**	**$36,331**	**$18,166**
PIEDMONT, CITY OF	1	2	$36,331	$18,166
WEBSTER COUNTY	**1**	**4**	**$123,809**	**$30,952**
WEBSTER COUNTY*	1	4	$123,809	$30,952
Grand Total	**1938**	**5806**	**$77,922,223**	**$14,288**

*Average payment is calculated as the mean of all properties' average payments within each community.

Source: SEMA, PIVOT

Severe Repetitive Loss Data

Table A.49 presents the number of severe repetitive loss properties by county along with the number of NFIP claims, paid losses, and average payment amount.

Table A.49. Missouri Severe Repetitive Loss County Summary

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
ANDREW COUNTY	**6**	**24**	**$1,409,506**	**$63,722**
ANDREW COUNTY*	5	22	$1,254,190	$60,935
NOVINGER, CITY OF	1	2	$155,316	$77,658
ATCHISON COUNTY	**1**	**2**	**$192,699**	**$96,350**
ATCHISON COUNTY*	1	2	$192,699	$96,350
BARRY COUNTY	**2**	**12**	**$676,348**	**$50,879**
MONETT, CITY OF	2	12	$676,348	$50,879
BATES COUNTY	**1**	**5**	**$197,295**	**$39,459**
BUTLER, CITY OF	1	5	$197,295	$39,459
BOLLINGER COUNTY	**2**	**7**	**$385,004**	**$72,705**
MARBLE HILL, CITY OF	2	7	$385,004	$72,705
BOONE COUNTY	**2**	**25**	**$3,013,752**	**$110,168**
BOONE COUNTY *	1	11	$260,163	$23,651
COLUMBIA, CITY OF	1	14	$2,753,589	$196,685
BUCHANAN COUNTY	**14**	**50**	**$3,427,827**	**$69,988**
AGENCY, TOWN OF	1	4	$173,142	$43,286
BUCHANAN COUNTY*	6	23	$1,744,525	$80,059
LEWIS AND CLARK, VILLAGE OF	7	23	$1,510,160	$65,171
BUTLER COUNTY	**4**	**16**	**$284,719**	**$20,560**
BUTLER COUNTY*	4	16	$284,719	$20,560
CALLAWAY COUNTY	**4**	**19**	**$805,711**	**$41,179**
JEFFERSON CITY, CITY OF	3	13	$749,853	$51,802
MOKANE, CITY OF	1	6	$55,858	$9,310
CAPE GIRARDEAU COUNTY	**14**	**74**	**$1,564,392**	**$23,323**
CAPE GIRARDEAU COUNTY*	4	23	$374,628	$18,891
CAPE GIRARDEAU, CITY OF	9	45	$1,045,573	$25,214
JACKSON, CITY OF	1	6	$144,191	$24,032
CARROLL COUNTY	**6**	**25**	**$1,139,631**	**$48,930**
CARROLL COUNTY*	3	10	$342,439	$42,193
CARROLLTON, TOWN OF	3	15	$797,192	$55,666
CARTER COUNTY	**2**	**8**	**$383,912**	**$47,989**
CARTER COUNTY*	2	8	$383,912	$47,989
CASS COUNTY	**11**	**64**	**$2,203,543**	**$36,914**
BIG LAKE, VILLAGE OF	1	2	$55,752	$27,876
CASS COUNTY *	4	22	$765,237	$36,669
EAST LYNNE, CITY OF	1	8	$184,380	$23,047

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
HARRISONVILLE, CITY OF	1	5	$625,830	$125,166
LAKE ANNETTE, CITY OF	1	8	$274,748	$34,343
PECULIAR, CITY OF	2	11	$216,159	$19,382
PLEASANT HILL, CITY OF	1	8	$81,438	$10,180
CHRISTIAN COUNTY	**2**	**11**	**$695,006**	**$59,335**
CHRISTIAN COUNTY *	1	5	$85,082	$17,016
OZARK, CITY OF	1	6	$609,924	$101,654
CLAY COUNTY	**14**	**134**	**$3,401,814**	**$24,371**
AVONDALE,CITY OF	1	10	$80,312	$8,031
CLAY COUNTY *	1	4	$22,242	$5,561
CLAYCOMO, VILLAGE OF	3	41	$1,759,095	$40,251
EXCELSIOR SPRINGS, CITY OF	3	27	$897,012	$34,297
KANSAS CITY, CITY OF	5	48	$385,796	$7,924
MOSBY, CITY OF	1	4	$257,359	$64,340
COLE COUNTY	**14**	**97**	**$2,860,906**	**$34,460**
COLE COUNTY*	10	65	$1,208,326	$19,696
JEFFERSON CITY, CITY OF	4	32	$1,652,580	$71,370
CRAWFORD COUNTY	**5**	**26**	**$2,551,225**	**$168,476**
CRAWFORD COUNTY*	5	26	$2,551,225	$168,476
FRANKLIN COUNTY	**33**	**139**	**$6,865,468**	**$49,566**
FRANKLIN COUNTY *	19	85	$4,826,847	$56,643
GASCONADE COUNTY*	1	6	$53,063	$8,844
PACIFIC, CITY OF	13	48	$1,985,558	$42,356
GASCONADE COUNTY	**26**	**160**	**$3,422,602**	**$21,040**
GASCONADE COUNTY*	21	129	$2,414,278	$19,972
HERMANN, CITY OF	5	31	$1,008,324	$25,526
GREENE COUNTY	**2**	**6**	**$393,333**	**$53,817**
MCDONALD COUNTY *	1	2	$37,200	$18,600
SPRINGFIELD, CITY OF	1	4	$356,133	$89,033
HOLT COUNTY	**62**	**262**	**$10,513,777**	**$41,063**
BIG LAKE, VILLAGE OF	61	260	$10,246,798	$39,548
HOLT COUNTY*	1	2	$266,979	$133,489
HOWELL COUNTY	**1**	**4**	**$844,131**	**$211,033**
WEST PLAINS, CITY OF	1	4	$844,131	$211,033
JACKSON COUNTY	**33**	**197**	**$11,399,946**	**$56,342**
INDEPENDENCE,CITY OF	1	6	$56,312	$9,385
JACKSON COUNTY *	1	6	$114,253	$19,042
KANSAS CITY, CITY OF	24	146	$10,679,794	$72,338
LEE'S SUMMIT, CITY OF	3	21	$311,621	$15,165
LEVASY, CITY OF	1	3	$20,179	$6,726
RAYTOWN, CITY OF	2	9	$113,518	$12,579
SUGAR CREEK, CITY OF	1	6	$104,268	$17,378

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
JASPER COUNTY	**2**	**9**	**$161,787**	**$18,438**
CARTHAGE, CITY OF	1	5	$71,408	$14,282
DUQUESNE, CITY OF	1	4	$90,379	$22,595
JEFFERSON COUNTY	**132**	**898**	**$24,753,934**	**$31,889**
ARNOLD, CITY OF	8	55	$1,087,673	$19,752
BYRNES MILL, CITY OF	1	7	$398,457	$56,922
CRYSTAL CITY,CITY OF	8	51	$2,189,428	$49,421
FENTON, CITY OF	2	24	$382,646	$16,056
FESTUS,CITY OF	2	18	$205,159	$15,664
HERCULANEUM, CITY OF	3	19	$730,788	$38,261
JEFFERSON COUNTY*	107	719	$19,507,480	$31,498
PULASKI COUNTY *	1	5	$252,303	$50,461
LACLEDE COUNTY	**1**	**4**	**$152,106**	**$38,026**
LACLEDE COUNTY *	1	4	$152,106	$38,026
LINCOLN COUNTY	**22**	**209**	**$3,803,374**	**$29,079**
ELSBERRY, CITY OF	1	2	$3,610	$1,805
FOLEY, CITY OF	3	19	$564,519	$34,727
LINCOLN COUNTY *	15	172	$2,635,033	$29,964
OLD MONROE, CITY OF	1	8	$514,606	$64,326
TROY, CITY OF	1	3	$21,372	$7,124
WINFIELD, CITY OF	1	5	$64,233	$12,847
MADISON COUNTY	**1**	**2**	**$360,228**	**$180,114**
MARQUAND, CITY OF	1	2	$360,228	$180,114
MARIES COUNTY	**7**	**26**	**$1,009,412**	**$40,718**
MARIES COUNTY*	6	22	$835,512	$40,259
PHELPS COUNTY*	1	4	$173,900	$43,475
MARION COUNTY	**2**	**16**	**$279,749**	**$18,540**
HANNIBAL, CITY OF	1	6	$136,582	$22,764
MARION COUNTY *	1	10	$143,167	$14,317
MCDONALD COUNTY	**12**	**78**	**$6,143,239**	**$73,276**
ANDERSON, CITY OF	2	5	$410,077	$86,805
MCDONALD COUNTY *	5	29	$1,180,785	$54,848
NOEL, CITY OF	5	44	$4,552,377	$86,292
MILLER COUNTY	**2**	**14**	**$207,967**	**$19,495**
ELDON,TOWN OF	1	10	$86,676	$8,668
OSAGE BEACH, CITY OF	1	4	$121,291	$30,323
MONTGOMERY COUNTY	**1**	**4**	**$43,011**	**$10,753**
GASCONADE COUNTY*	1	4	$43,011	$10,753
NEWTON COUNTY	**7**	**26**	**$1,163,671**	**$52,739**
GRAND FALLS PLAZA, TOWN OF	1	4	$125,930	$31,483
JOPLIN, CITY OF	1	2	$52,931	$26,466
NEOSHO, CITY OF	1	6	$89,099	$14,850

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
NEWTON COUNTY *	4	14	$895,711	$74,093
OREGON COUNTY	**3**	**25**	**$492,365**	**$22,320**
ST. CHARLES COUNTY *	2	16	$181,388	$16,203
WEST ALTON, TOWN OF	1	9	$310,976	$34,553
OSAGE COUNTY	**3**	**15**	**$348,133**	**$24,042**
CHAMOIS, CITY OF	2	9	$294,641	$31,605
WESTPHALIA, CITY OF	1	6	$53,492	$8,915
PETTIS COUNTY	**1**	**2**	**$154,771**	**$77,385**
PETTIS COUNTY *	1	2	$154,771	$77,385
PHELPS COUNTY	**16**	**58**	**$4,899,684**	**$89,799**
MARIES COUNTY*	1	3	$805,998	$268,666
PHELPS COUNTY*	13	48	$3,714,240	$81,664
ROLLA, CITY OF	1	4	$239,938	$59,985
WILSON CITY, CITY OF	1	3	$139,508	$46,503
PIKE COUNTY	**23**	**253**	**$3,481,738**	**$16,281**
ANNADA, VILLAGE OF	1	9	$92,436	$10,271
CLARKSVILLE, CITY OF	6	44	$595,546	$16,923
LOUISIANA, CITY OF	5	59	$1,196,046	$24,552
PIKE COUNTY *	11	141	$1,597,710	$12,719
PLATTE COUNTY	**8**	**32**	**$1,424,384**	**$56,036**
PLATTE COUNTY*	7	29	$1,327,728	$59,438
WESTON, CITY OF	1	3	$96,656	$32,219
PULASKI COUNTY	**10**	**33**	**$1,792,067**	**$53,458**
PHELPS COUNTY*	1	4	$117,346	$29,336
PULASKI COUNTY *	9	29	$1,674,722	$56,139
RAY COUNTY	**1**	**6**	**$64,602**	**$10,767**
RAY COUNTY *	1	6	$64,602	$10,767
REYNOLDS COUNTY	**1**	**2**	**$110,027**	**$55,014**
REYNOLDS COUNTY*	1	2	$110,027	$55,014
RIPLEY COUNTY	**11**	**52**	**$2,549,397**	**$61,408**
DONIPHAN, CITY OF	3	22	$366,289	$15,633
RIPLEY COUNTY*	8	30	$2,183,108	$78,573
SCOTT COUNTY	**2**	**30**	**$1,056,868**	**$35,229**
SCOTT COUNTY*	2	30	$1,056,868	$35,229
ST. CHARLES COUNTY	**190**	**1639**	**$39,908,700**	**$24,108**
LINCOLN COUNTY *	2	10	$98,405	$9,841
O'FALLON, CITY OF	2	8	$306,192	$46,647
OSAGE COUNTY*	1	2	$30,769	$15,384
PORTAGE DES SIOUX, CITY OF	10	184	$7,886,929	$29,382
ST. CHARLES COUNTY *	130	1076	$22,745,890	$22,593
ST. CHARLES, CITY OF	7	68	$1,881,263	$34,273
ST. PETERS, CITY OF	1	11	$182,234	$16,567

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
WEST ALTON, TOWN OF	37	280	$6,777,018	$26,073
ST. FRANCOIS COUNTY	**2**	**25**	**$868,971**	**$29,274**
ST. FRANCOIS COUNTY*	2	25	$868,971	$29,274
ST. LOUIS CITY	**2**	**26**	**$768,010**	**$30,905**
ST. LOUIS, CITY OF	2	26	$768,010	$30,905
ST. LOUIS COUNTY	**131**	**932**	**$51,040,046**	**$57,867**
BALLWIN, CITY OF	1	8	$36,914	$4,614
BRECKENRIDGE HILLS, CITY OF	1	6	$81,354	$13,559
BRENTWOOD, CITY OF	28	192	$18,265,045	$86,753
DES PERES, CITY OF	2	11	$184,456	$16,298
EUREKA, CITY OF	4	21	$562,356	$29,210
FENTON, CITY OF	14	121	$4,312,229	$37,519
FERGUSON, CITY OF	1	6	$405,742	$67,624
FRANKLIN COUNTY *	1	6	$64,890	$10,815
FRONTENAC, CITY OF	1	4	$1,633,272	$408,318
GASCONADE COUNTY*	1	5	$35,092	$7,018
GLENDALE, CITY OF	1	2	$34,361	$17,181
HAZELWOOD, CITY OF	4	24	$2,308,241	$110,082
KIRKWOOD, CITY OF	4	32	$934,401	$38,204
LADUE,CITY OF	3	19	$1,006,851	$52,100
LINCOLN COUNTY *	1	11	$114,918	$10,447
MACKENZIE, VILLAGE OF	1	5	$54,864	$10,973
MANCHESTER, CITY OF	3	17	$947,339	$67,373
ROCK HILL, CITY OF	4	40	$5,898,856	$150,086
ST. CHARLES COUNTY *	2	13	$164,748	$11,614
ST. LOUIS COUNTY *	33	226	$7,442,019	$46,765
ST. LOUIS, CITY OF	1	9	$377,740	$41,971
SUNSET HILLS, CITY OF	4	29	$571,663	$20,209
TOWN AND COUNTRY, CITY OF	1	4	$157,711	$39,428
UNIVERSITY CITY, CITY OF	5	57	$3,090,544	$41,157
VALLEY PARK, CITY OF	8	57	$1,909,772	$37,881
WILDWOOD, CITY OF	2	7	$444,668	$68,370
STE. GENEVIEVE COUNTY	**16**	**103**	**$1,962,022**	**$15,407**
ST. MARY, CITY OF	1	3	$48,889	$16,296
STE. GENEVIEVE COUNTY*	2	13	$287,869	$22,134
STE. GENEVIEVE, CITY OF	13	87	$1,625,264	$14,303
STODDARD COUNTY	**1**	**5**	**$66,755**	**$13,351**
COMMERCE, CITY OF	1	5	$66,755	$13,351
STONE COUNTY	**2**	**8**	**$690,937**	**$91,848**
REEDS SPRING, CITY OF	1	5	$349,623	$69,925
STONE COUNTY*	1	3	$341,314	$113,771
TANEY COUNTY	**20**	**83**	**$7,957,780**	**$105,795**

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
BRANSON, CITY OF	5	23	$1,206,054	$59,086
HOLLISTER, CITY OF	1	4	$90,001	$22,500
ROCKAWAY BEACH, CITY OF	1	7	$52,213	$7,459
TANEY COUNTY*	13	49	$6,609,512	$137,731
WARREN COUNTY	**1**	**4**	**$59,096**	**$14,774**
MARTHASVILLE, CITY OF	1	4	$59,096	$14,774
WAYNE COUNTY	**1**	**7**	**$142,993**	**$20,428**
PIEDMONT, CITY OF	1	7	$142,993	$20,428
Grand Total	**895**	**5993**	**$216,550,369**	**$41,842**

*Average payment is calculated as the mean of all properties' average payments within each community.

Source: SEMA, PIVOT

Severe Repetitive Loss Data – MITIGATED

Table A.50 presents the number of mitigated severe repetitive loss properties by county along with the number of NFIP claims, paid losses, and average payment amount.

Table A.50. Missouri Mitigated Severe Repetitive Loss County Summary

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
ANDREW COUNTY	**1**	**3**	**$81,906**	**$27,302**
ANDREW COUNTY*	1	3	$81,906	$27,302
BUTLER COUNTY	**1**	**4**	**$83,777**	**$20,944**
BUTLER COUNTY*	1	4	$83,777	$20,944
CALLAWAY COUNTY	**1**	**9**	**$56,016**	**$6,224**
MOKANE, CITY OF	1	9	$56,016	$6,224
CAPE GIRARDEAU COUNTY	**8**	**40**	**$504,151**	**$12,015**
CAPE GIRARDEAU, CITY OF	8	40	$504,151	$12,015
CHRISTIAN COUNTY	**1**	**7**	**$121,668**	**$17,381**
OZARK, CITY OF	1	7	$121,668	$17,381
CLAY COUNTY	**1**	**7**	**$101,581**	**$14,512**
MOSBY, CITY OF	1	7	$101,581	$14,512
COLE COUNTY	**1**	**8**	**$111,652**	**$13,956**
JEFFERSON CITY, CITY OF	1	8	$111,652	$13,956
FRANKLIN COUNTY	**3**	**8**	**$331,370**	**$43,451**
EUREKA, CITY OF	1	4	$141,331	$35,333
PACIFIC, CITY OF	2	4	$190,039	$47,510
GASCONADE COUNTY	**1**	**2**	**$27,420**	**$13,710**
HERMANN, CITY OF	1	2	$27,420	$13,710
GREENE COUNTY	**1**	**3**	**$281,084**	**$93,695**
GREENE COUNTY *	1	3	$281,084	$93,695
HOLT COUNTY	**28**	**103**	**$4,491,171**	**$44,701**
BIG LAKE, VILLAGE OF	26	95	$4,192,635	$45,269
HOLT COUNTY*	2	8	$298,536	$37,317
JACKSON COUNTY	**3**	**16**	**$1,124,843**	**$73,730**
KANSAS CITY, CITY OF	3	16	$1,124,843	$73,730
JEFFERSON COUNTY	**53**	**346**	**$6,868,654**	**$19,868**
ARNOLD, CITY OF	18	114	$2,297,763	$21,765
CRYSTAL CITY,CITY OF	5	29	$404,899	$14,646
JEFFERSON COUNTY*	27	185	$3,788,560	$19,404
PEVELY, CITY OF	1	6	$90,501	$15,084
SCOTSDALE, VILLAGE OF	1	5	$140,279	$28,056
ST. LOUIS COUNTY *	1	7	$146,652	$20,950
LINCOLN COUNTY	**16**	**89**	**$1,610,594**	**$17,895**
CHAIN OF ROCKS, VILLAGE OF	1	6	$219,956	$36,659
FOLEY, CITY OF	1	4	$62,240	$15,560

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
LINCOLN COUNTY *	12	69	$1,219,631	$16,669
WINFIELD, CITY OF	2	10	$108,767	$17,038
MARIES COUNTY	**1**	**4**	**$69,315**	**$17,329**
MARIES COUNTY*	1	4	$69,315	$17,329
OSAGE COUNTY	**1**	**2**	**$45,717**	**$22,858**
OSAGE COUNTY*	1	2	$45,717	$22,858
PEMISCOT COUNTY	**1**	**4**	**$98,238**	**$24,560**
CARUTHERSVILLE, CITY OF	1	4	$98,238	$24,560
PHELPS COUNTY	**2**	**7**	**$520,256**	**$72,133**
PHELPS COUNTY*	2	7	$520,256	$72,133
PIKE COUNTY	**2**	**28**	**$258,816**	**$9,547**
PIKE COUNTY *	2	28	$258,816	$9,547
PLATTE COUNTY	**1**	**9**	**$361,060**	**$40,118**
PLATTE COUNTY*	1	9	$361,060	$40,118
PULASKI COUNTY	**1**	**4**	**$99,014**	**$24,753**
WAYNESVILLE, CITY OF	1	4	$99,014	$24,753
SCOTT COUNTY	**1**	**6**	**$67,769**	**$11,295**
COMMERCE, CITY OF	1	6	$67,769	$11,295
ST. CHARLES COUNTY	**220**	**1651**	**$25,777,064**	**$16,108**
PORTAGE DES SIOUX, CITY OF	10	65	$1,028,882	$16,097
ST. CHARLES COUNTY *	199	1461	$22,874,158	$16,146
ST. CHARLES, CITY OF	4	36	$424,268	$12,295
ST. LOUIS COUNTY *	1	31	$470,569	$15,180
ST. PETERS, CITY OF	1	14	$248,549	$17,754
WEST ALTON, TOWN OF	5	44	$730,638	$17,520
ST. FRANCOIS COUNTY	**1**	**4**	**$71,654**	**$17,913**
BONNE TERRE, CITY OF	1	4	$71,654	$17,913
ST. LOUIS COUNTY	**151**	**998**	**$20,461,791**	**$22,635**
BRENTWOOD, CITY OF	6	38	$556,207	$16,300
CHESTERFIELD, CITY OF	1	7	$43,084	$6,155
FENTON, CITY OF	17	110	$1,744,809	$15,431
MARYLAND HEIGHTS, CITY OF	1	5	$118,456	$23,691
ST. CHARLES COUNTY *	4	30	$408,142	$13,703
ST. LOUIS COUNTY *	46	309	$5,247,548	$16,996
ST. LOUIS, CITY OF	2	9	$126,402	$14,034
SUNSET HILLS, CITY OF	3	17	$208,924	$12,899
UNIVERSITY CITY, CITY OF	13	128	$1,366,944	$11,150
VALLEY PARK, CITY OF	58	345	$10,641,275	$34,130
STE. GENEVIEVE COUNTY	**4**	**20**	**$236,599**	**$12,447**
STE. GENEVIEVE, CITY OF	4	20	$236,599	$12,447
TANEY COUNTY	**3**	**6**	**$775,951**	**$129,325**
BRANSON, CITY OF	3	6	$775,951	$129,325

County and Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
WASHINGTON COUNTY	**1**	**4**	**$72,028**	**$18,007**
ALTON, CITY OF	1	4	$72,028	$18,007
Grand Total	**509**	**3392**	**$64,711,158**	**$21,583**

*Average payment is calculated as the mean of all properties' average payments within each community.

Source: SEMA, PIVOT

Appendix B

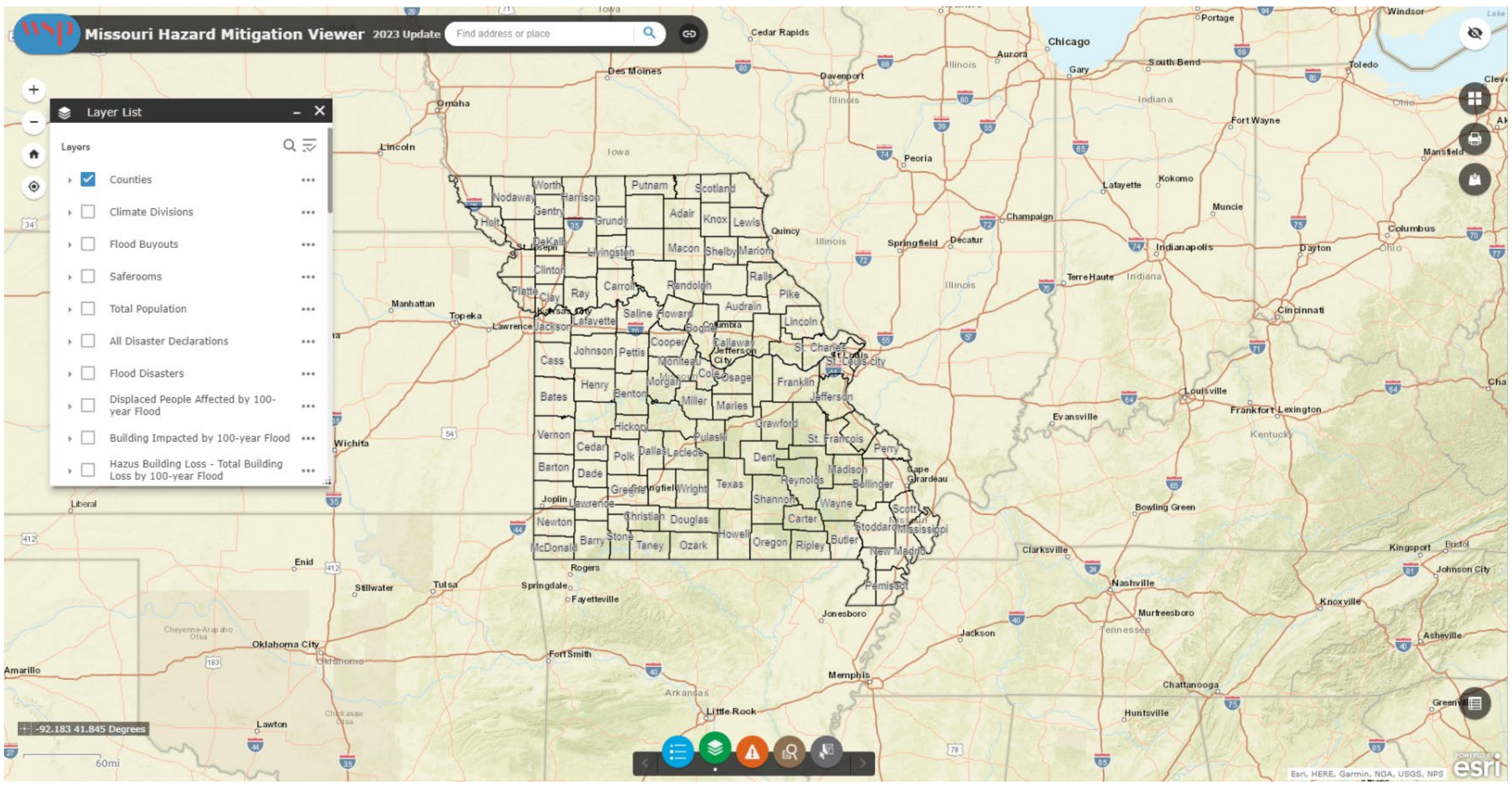
Missouri Hazard Mitigation Viewer User Guide

MISSOURI
DEPT OF PUBLIC SAFETY
SERVICE SECURITY SAFETY
EMERGENCY MANAGEMENT

Introduction

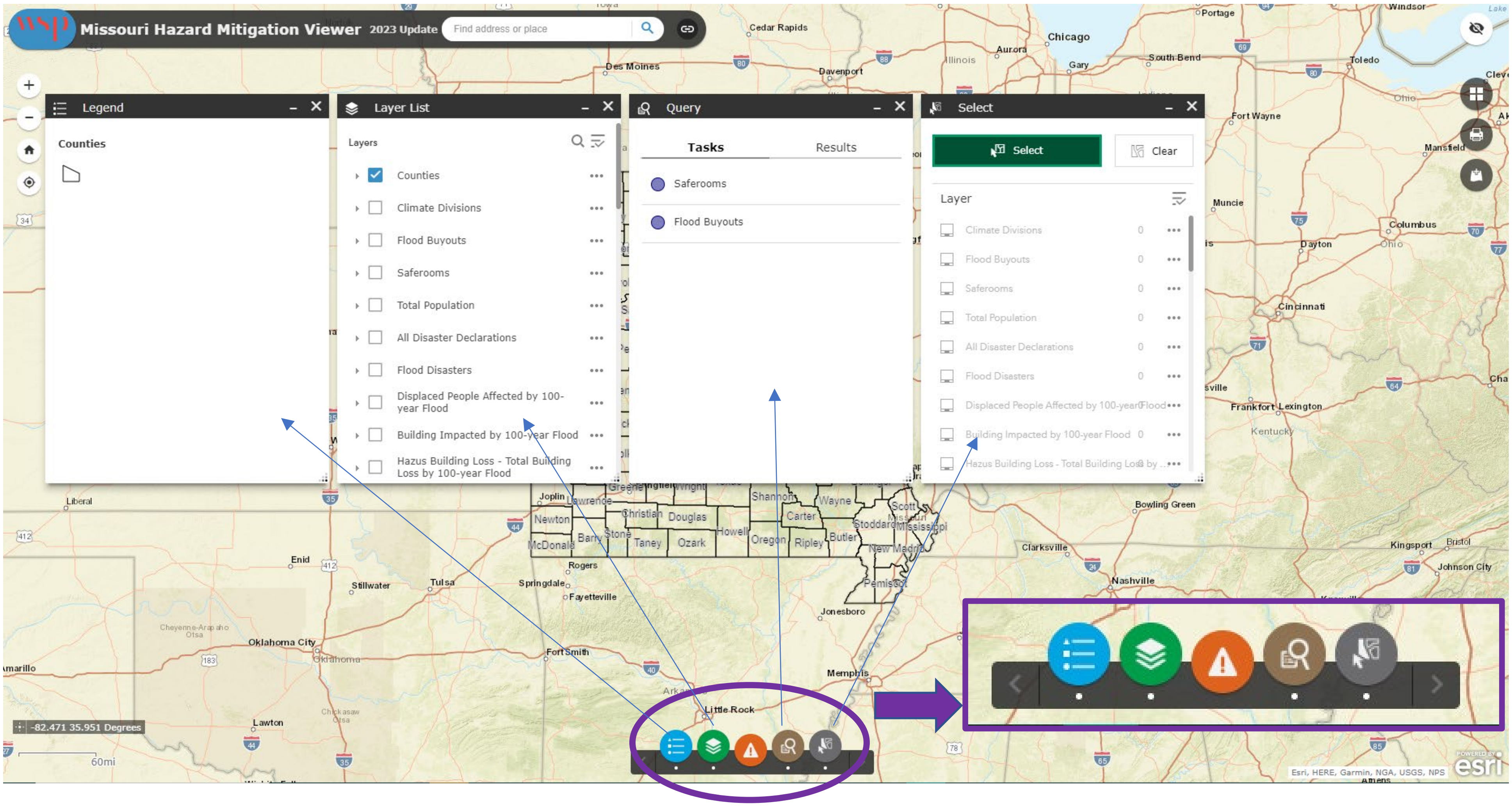
With the 2023 Hazard Mitigation Plan Update, SEMA is pleased to continue to provide online access to the risk assessment data and associated mapping for the 114 counties in the State, including the Independent City of St. Louis. Through the web-based **Missouri Hazard Mitigation Viewer**, local planners or other interested parties can obtain all State Plan datasets. This effort removes from local mitigation planners a barrier to performing all the needed local risk assessments by providing the data developed during the 2023 State Plan Update.

Functionality will consolidate all data layers developed or provided by SEMA planners and partners (State and Local) into one central location. The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2023 State Plan for easy reference, search and query capabilities, ability to zoom to county level data and capability to download PDF format maps. The Missouri Hazard Mitigation Viewer can be found at this link: http://bit.ly/MoHazardMitigationPlanViewer2023. Figure 1 below shows how the page looks when you first open it.

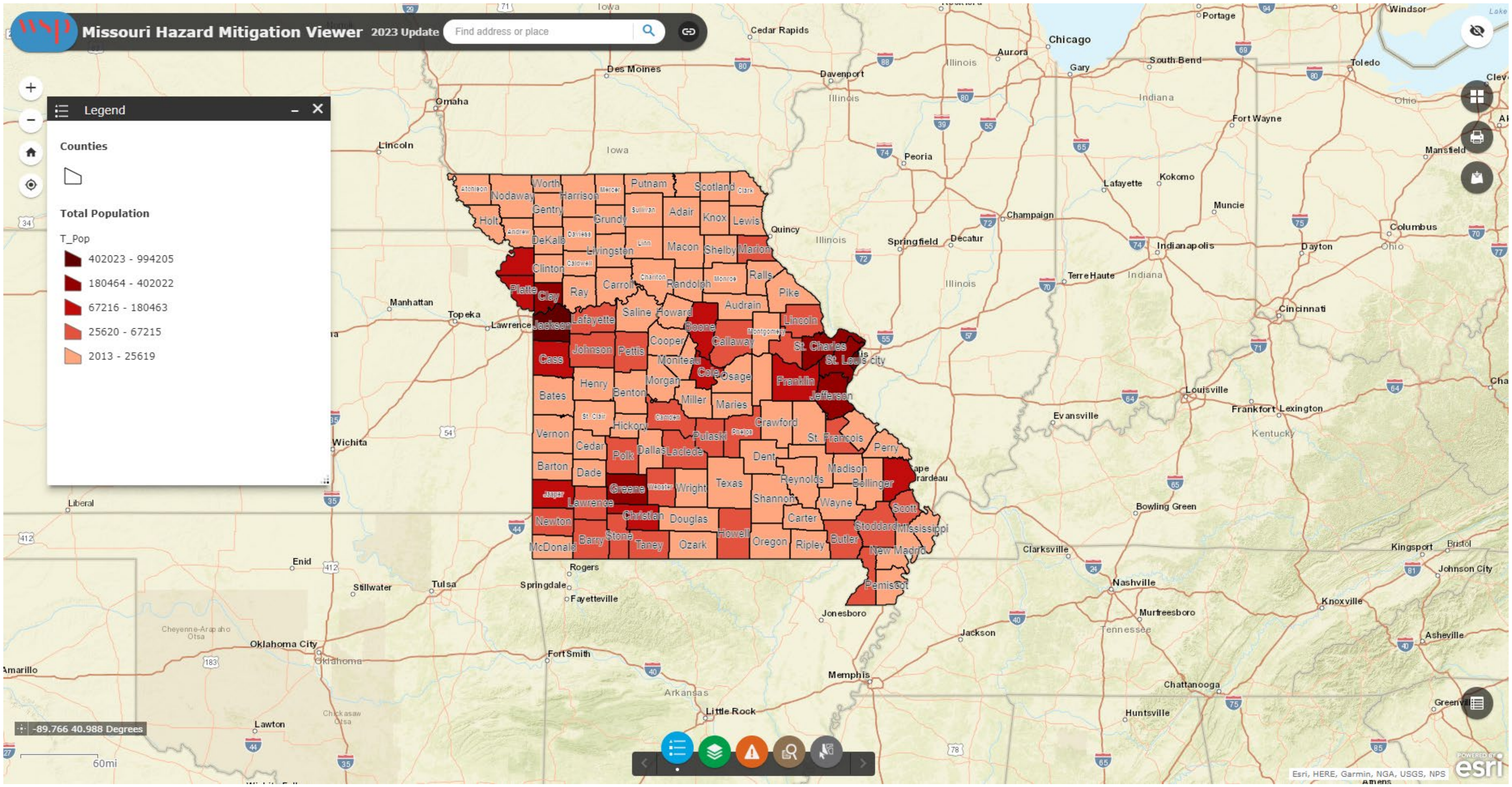


User Guide Instructions

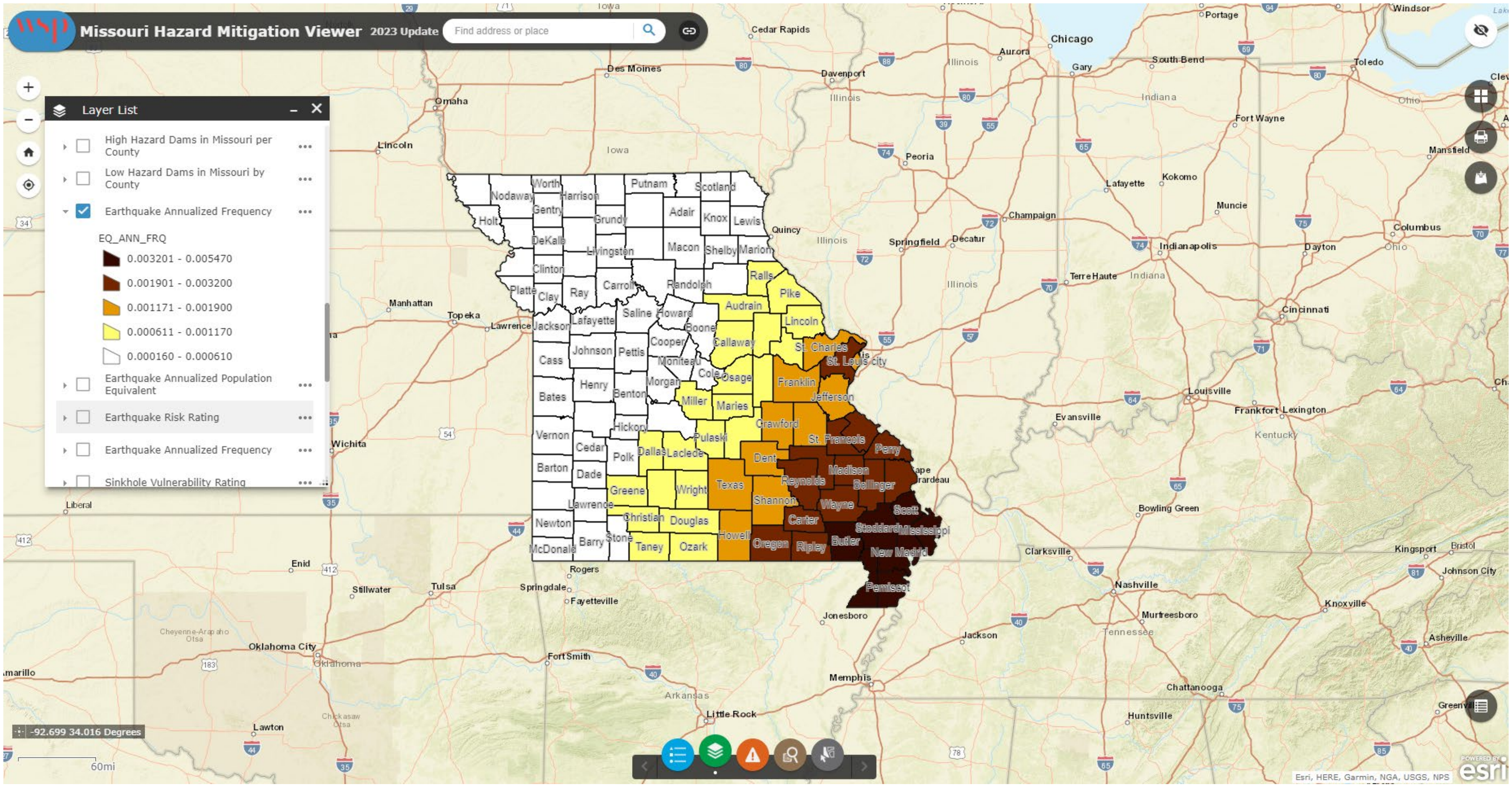
By clicking on the five buttons at the bottom center of the page, windows will open as shown in Figure 2 below. From left to right, these buttons: Legend, Layer List, Query and Select. The orange button in the center is the Loss Avoidance Tool and will be covered in a separate User Guide.



The Legend window shows the symbology or the colors of the layers that are turned on or active as shown in the example below. These layers match the pdfs shown in the 2023 Hazard Mitigation Plan.



The Layer List button activates the window where the Operational Layers can be turned on/off or made active/inactive. There are two levels of Operational Layers that will need to be turned on as shown in the example below. Both levels are defaulted off except the county basemap layer. The Earthquake Hazard example below shows the Earthquake Annualized Frequency active.



In the upper left corner of the Viewer, are the buttons which control zoom.

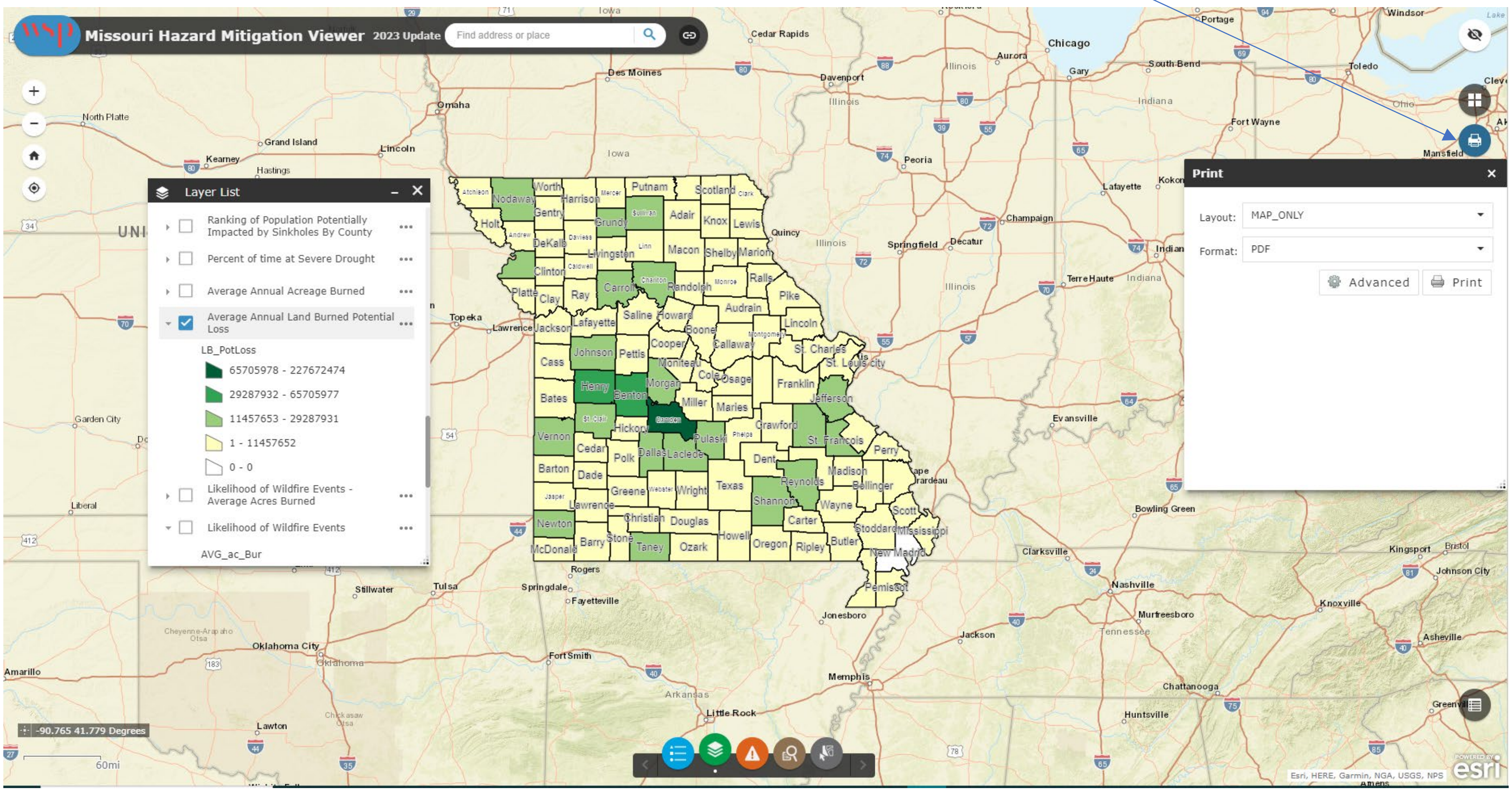
The plus sign zooms in.

The minus sign zooms out.

The Home or house icon returns the map to full scale and centers it on the user's screen display.

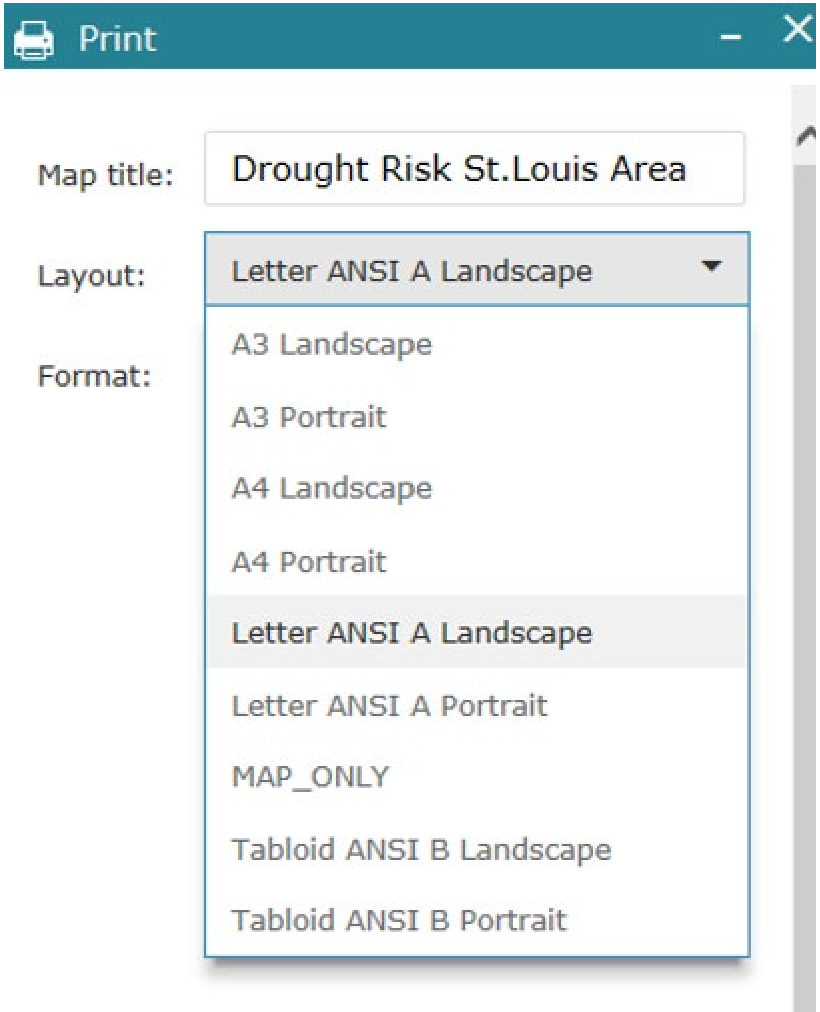
In the upper right corner of the Viewer, is the Overview button. Clicking on this icon opens a wide-angle map showing where the current selection is located inside the wider view. This is a toggle button. To close out the Overview map, tap the icon again and it will close.

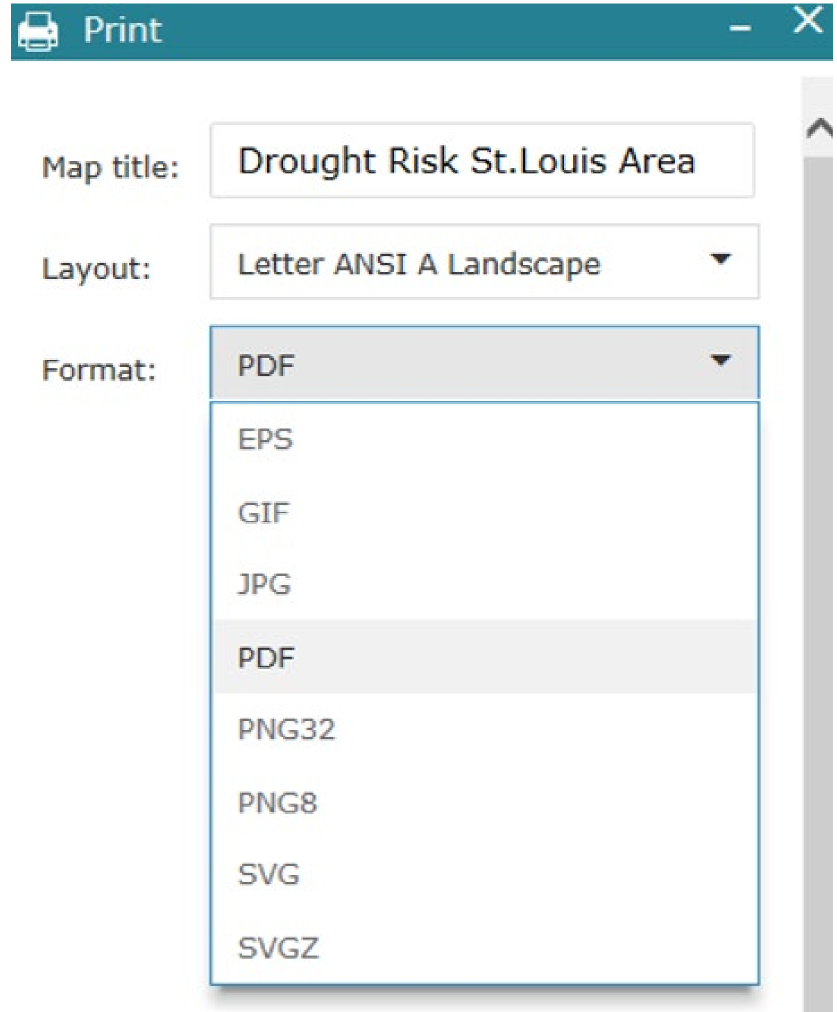
The Print function, found on the right side of the page near the top, allows the user to create maps. The map title can be customized.



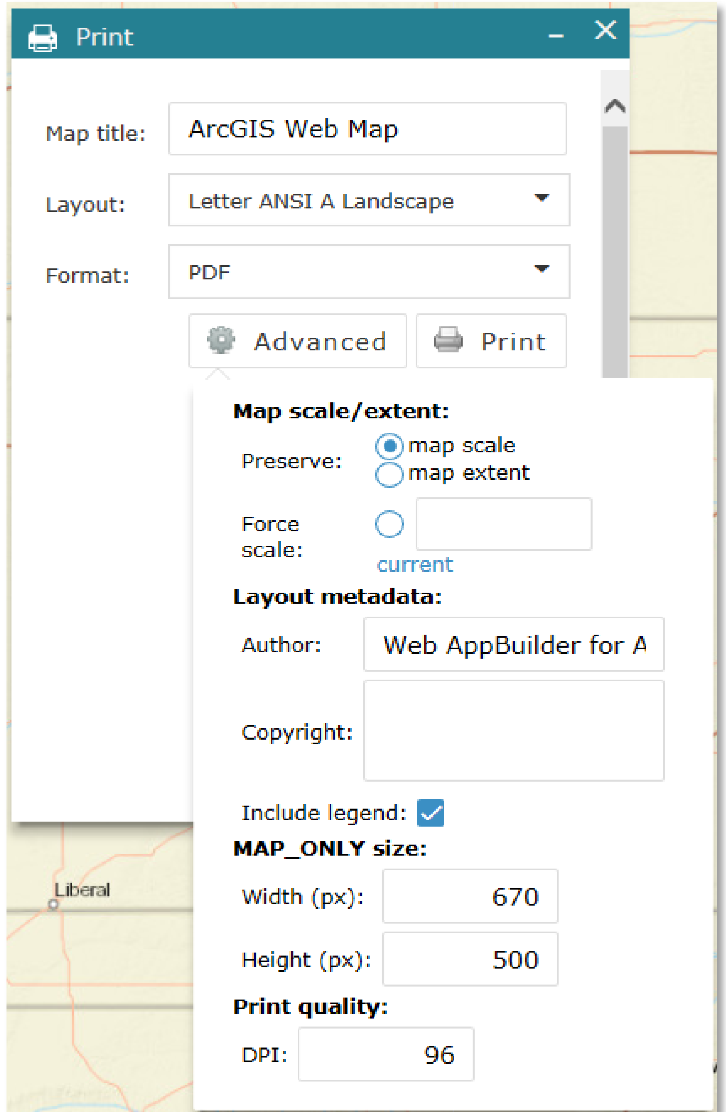
The dropdown list under Layout provides options for standard sizes of maps.

The dropdown menu under Format provides options for standard types of digital files.

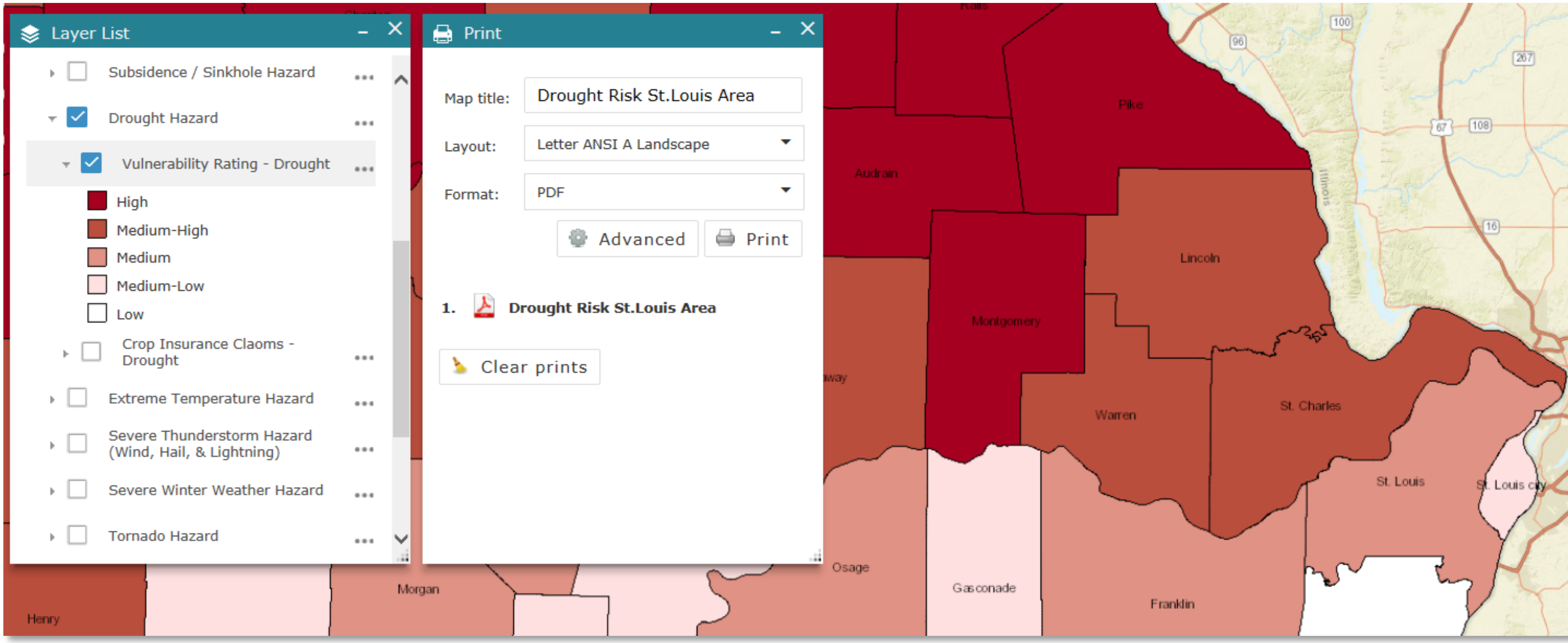




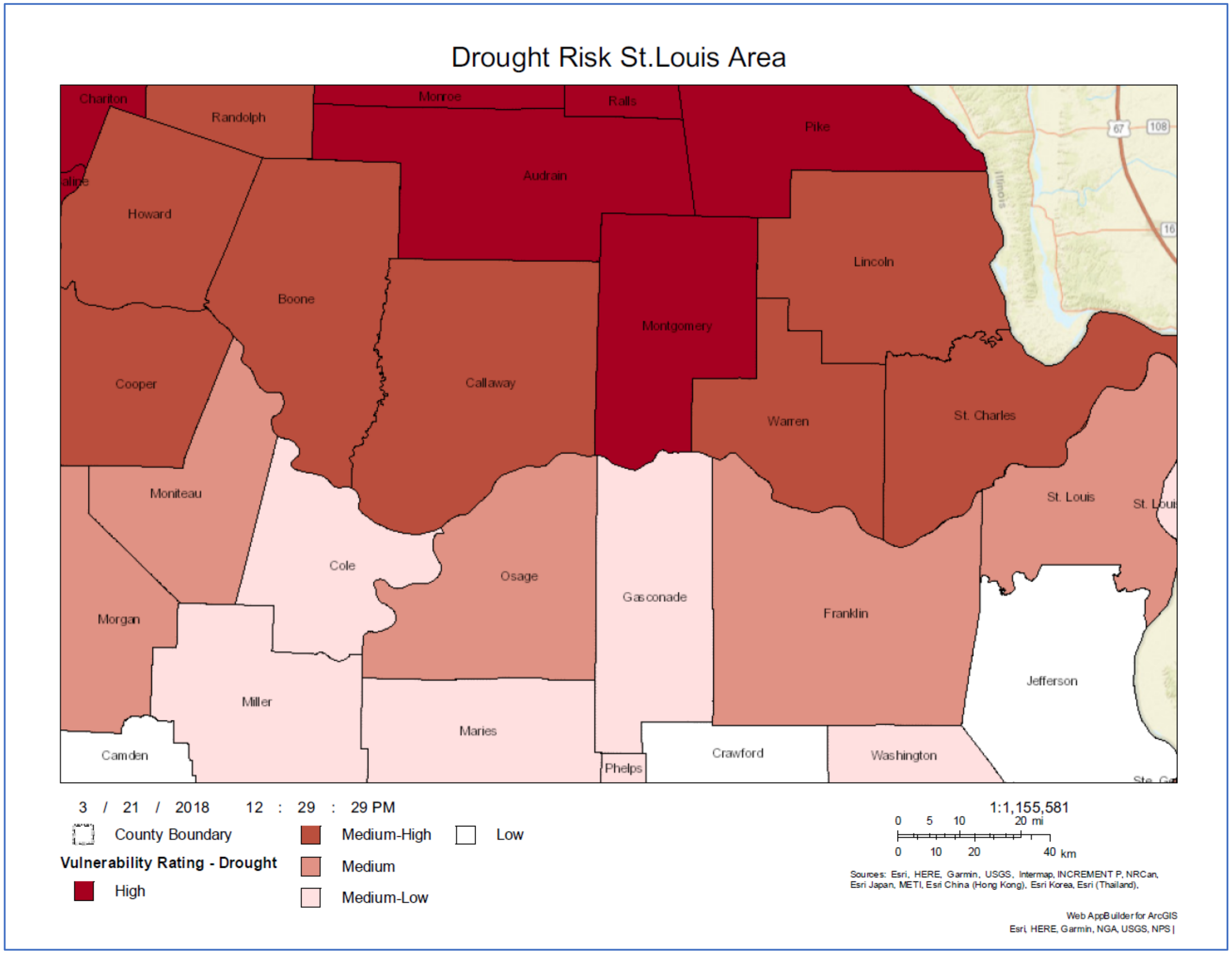
Options for scale, metadata, map only size and print quality can be found under the Advanced Button.



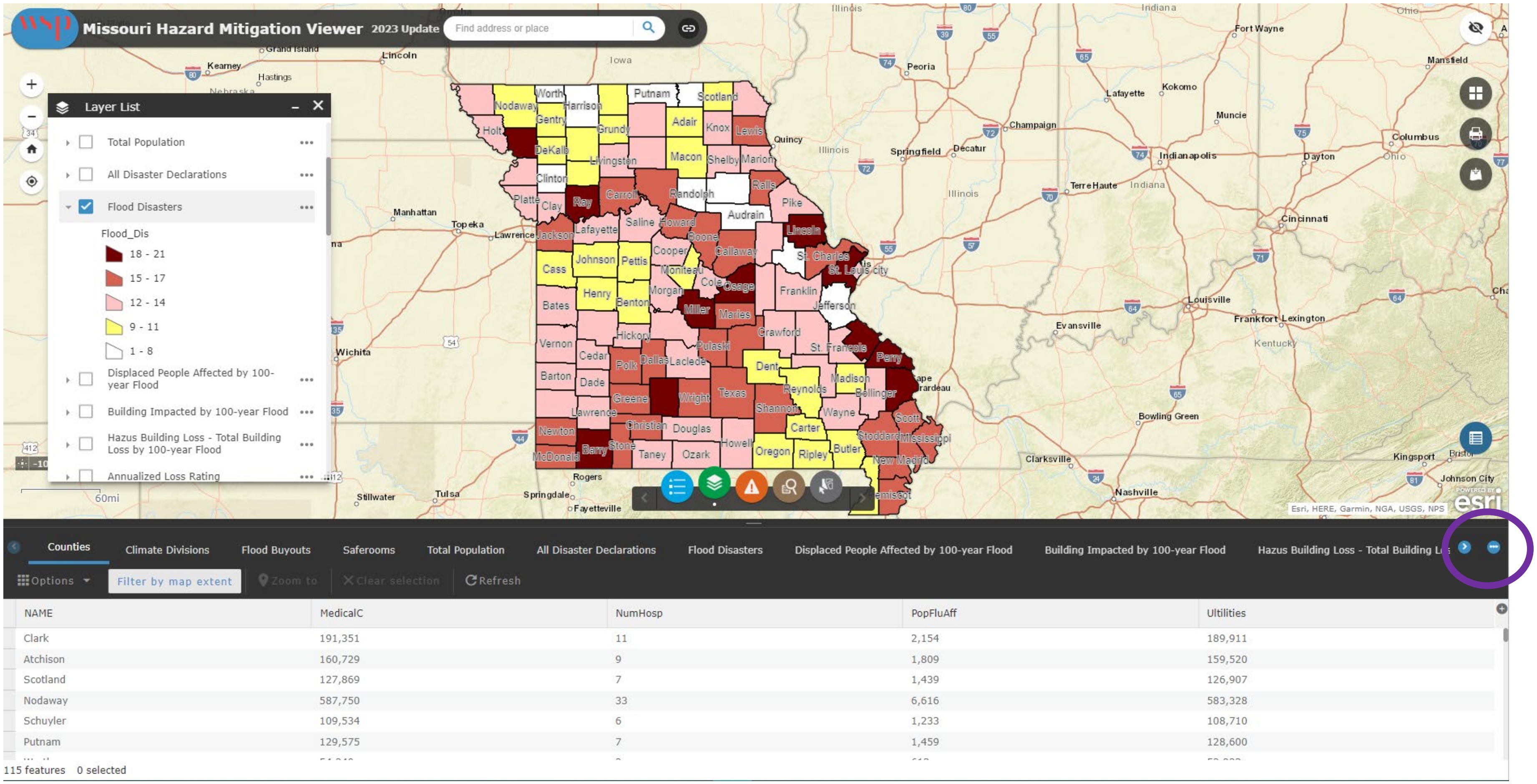
Clicking on the Print Button will create the custom map in the digital format.



Clicking on the map name, in this example Drought Risk St. Louis Area, will open the digital file created which can be saved to the user's computer or printed. This opens automatically in a new internet tab. To close it out, close the tab. The Mitigation Viewer tab will still be open to the last selection.

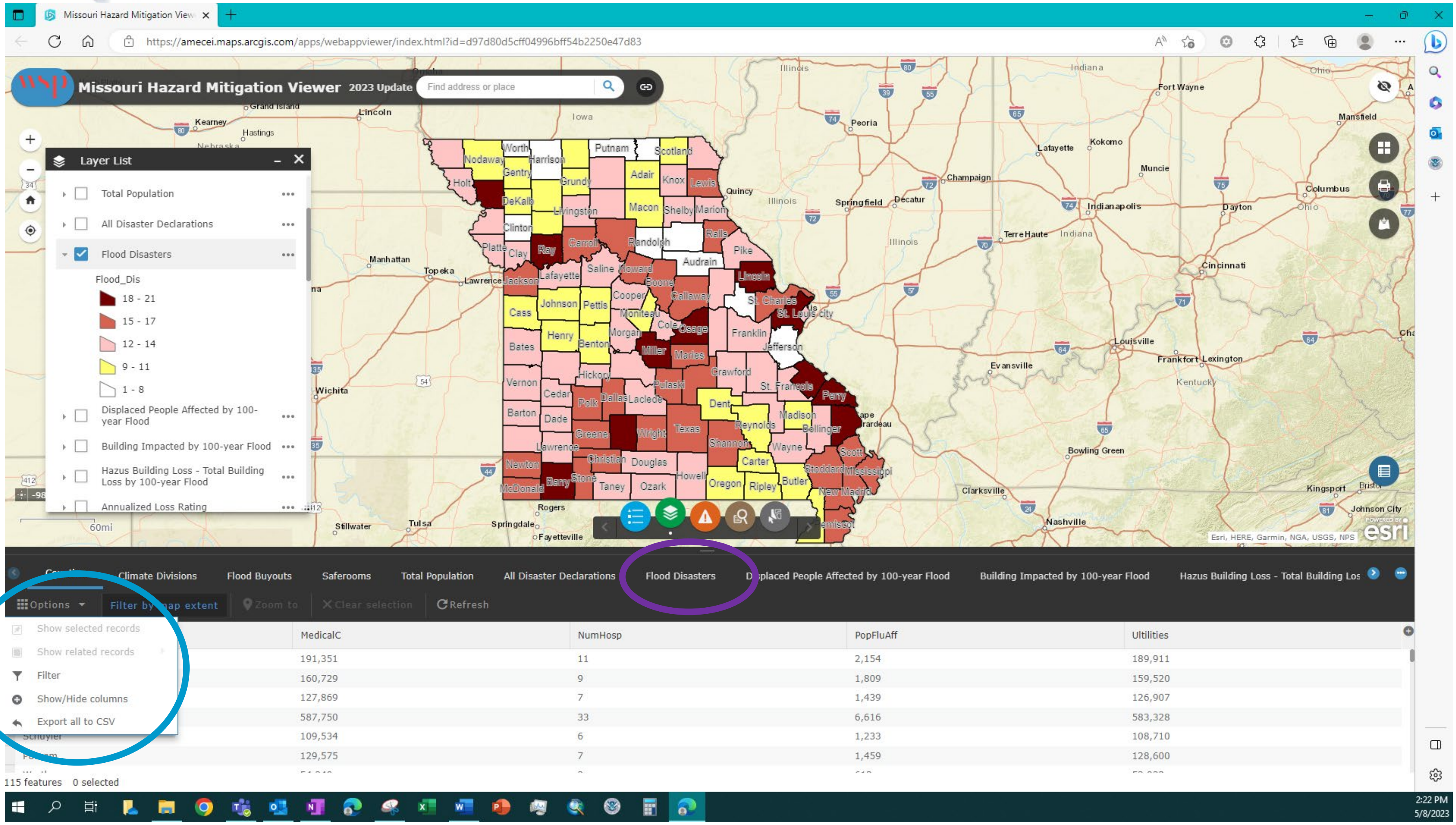


In the bottom right corner of the Viewer is the **Attributes** button. This is also a toggle button. Click once to open the attributes table, tap again to close it. The attributes table for the active map will display at the bottom of the screen.



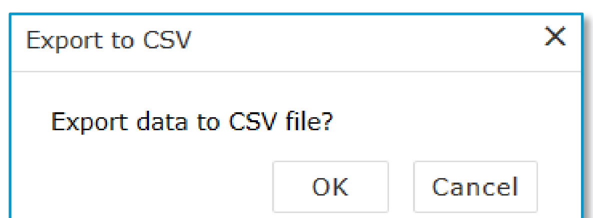
This data can be exported into a CSV format file that can then be used by many different formats. To export, the attributes table much be active as shown above. Click the blue button on the upper right hand of the attribute table, circled in purple above.

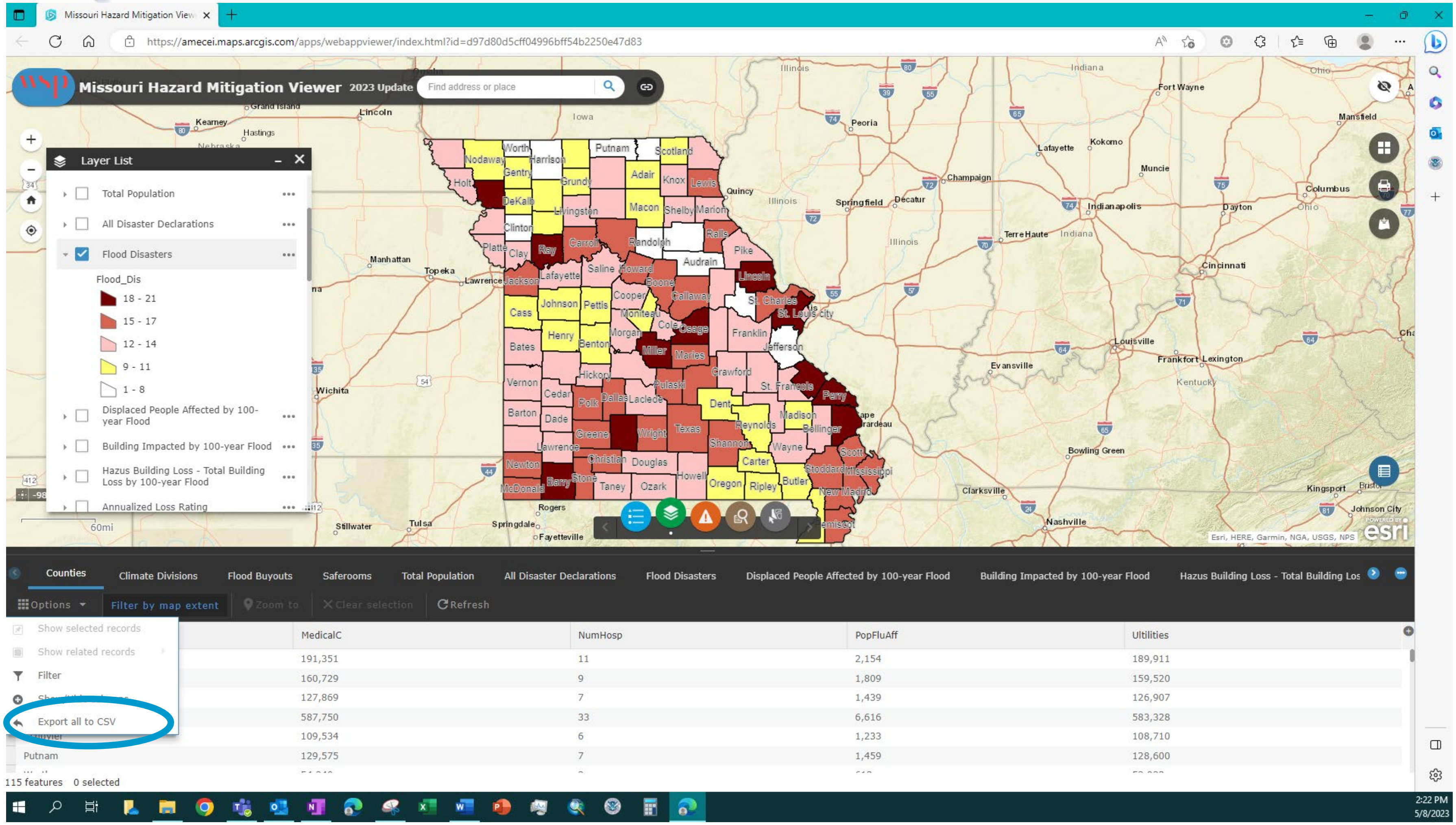
A window will appear on the right side that shows the various tables available for download. Highlight the table needed by clicking on it as shown below. That Attribute table will be zoomed to and shown as noted on the dark bar inside the purple circle.



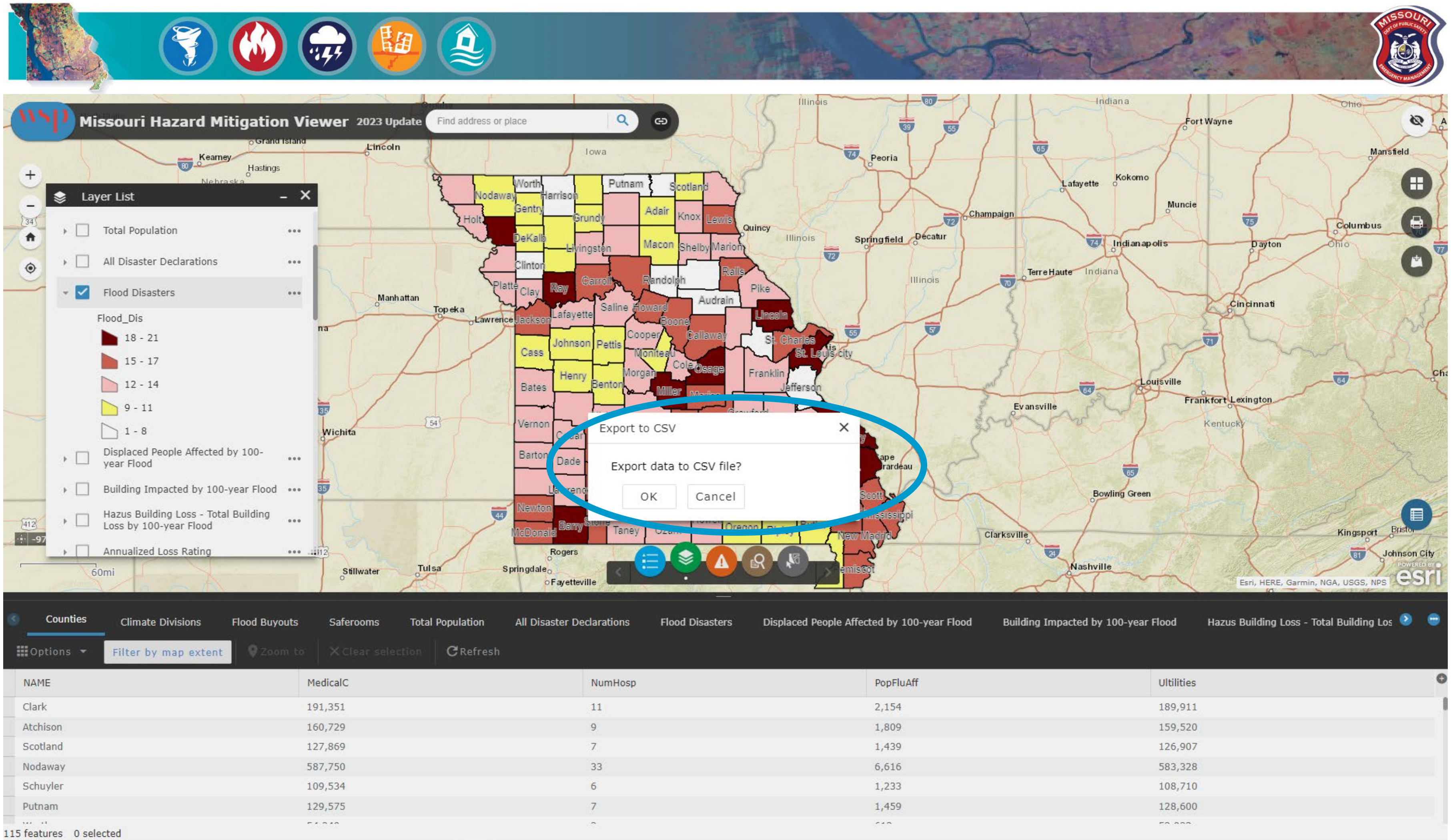
Click on the Options tab, circled in teal in the graphic above.

Choose the **Export to CSV option**. A small window will open. Click “Ok”.





In the middle of the page, a small box will appear asking if you want to save the file. Click “OK” and check your downloads folder.


Missouri Hazard Mitigation Viewer 2023 Update
Find address or place
Layer List
Total Population
All Disaster Declarations
Flood Disasters
Flood_Dis
18 - 21
15 - 17
12 - 14
9 - 11
1 - 8
Displaced People Affected by 100-year Flood
Building Impacted by 100-year Flood
Hazus Building Loss - Total Building Loss by 100-year Flood
Annualized Loss Rating
Export to CSV
Export data to CSV file?
OK
Cancel
Counties
Climate Divisions
Flood Buyouts
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Total Population
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Flood Disasters
Displaced People Affected by 100-year Flood
Building Impacted by 100-year Flood
Options
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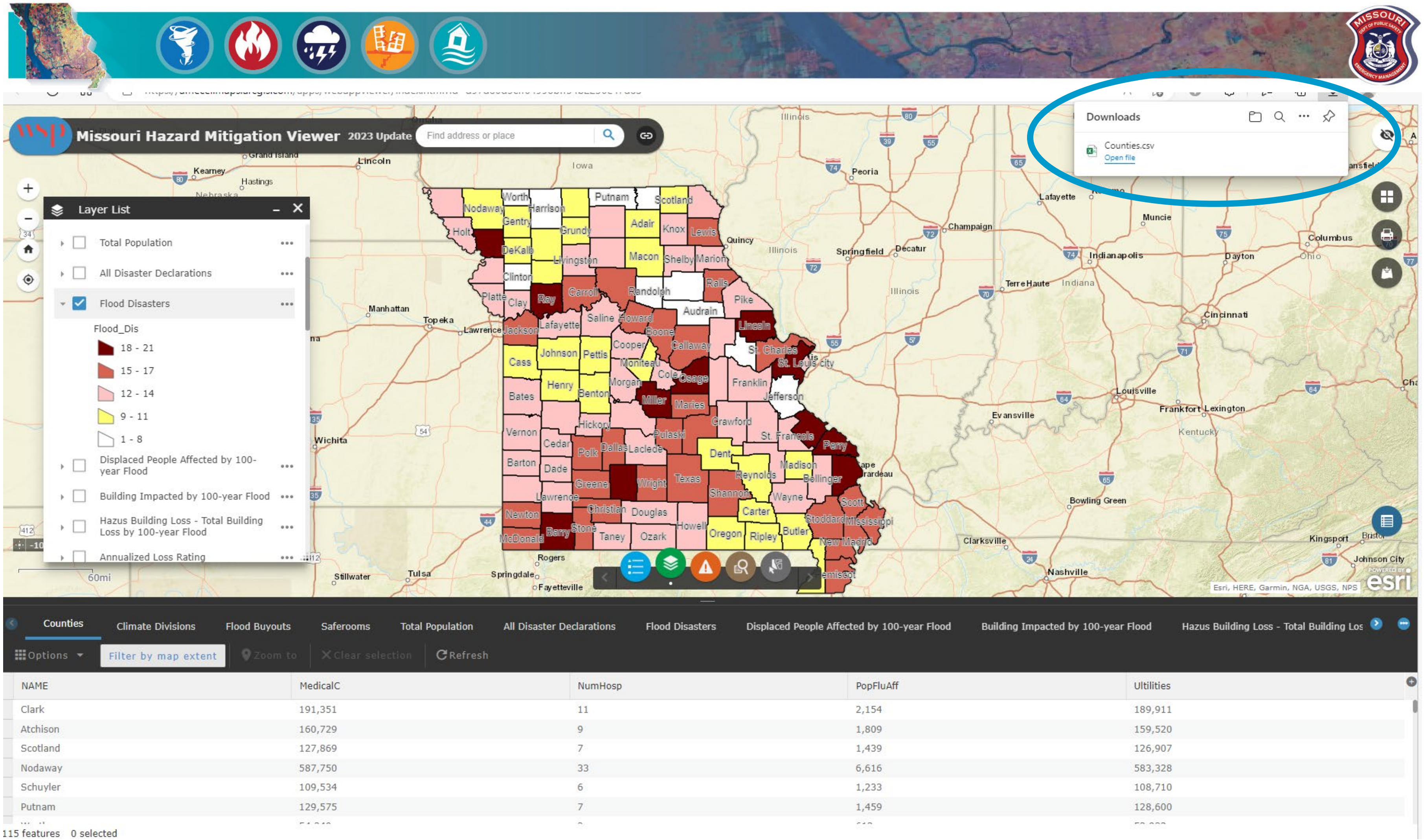
Atchison 160,729 9 1,809 159,520
Scotland 127,869 7 1,439 126,907
Nodaway 587,750 33 6,616 583,328
Schuyler 109,534 6 1,233 108,710
Putnam 129,575 7 1,459 128,600
115 features 0 selected


Missouri Hazard Mitigation Viewer 2023 Update
Find address or place
Downloads
Counties.csv
Open file
Layer List
Total Population
All Disaster Declarations
Flood Disasters
Flood_Dis
18 - 21
15 - 17
12 - 14
9 - 11
1 - 8
Displaced People Affected by 100-year Flood
Building Impacted by 100-year Flood
Hazus Building Loss - Total Building Loss by 100-year Flood
Annualized Loss Rating
Counties
Climate Divisions
Flood Buyouts
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Total Population
All Disaster Declarations
Flood Disasters
Displaced People Affected by 100-year Flood
Building Impacted by 100-year Flood
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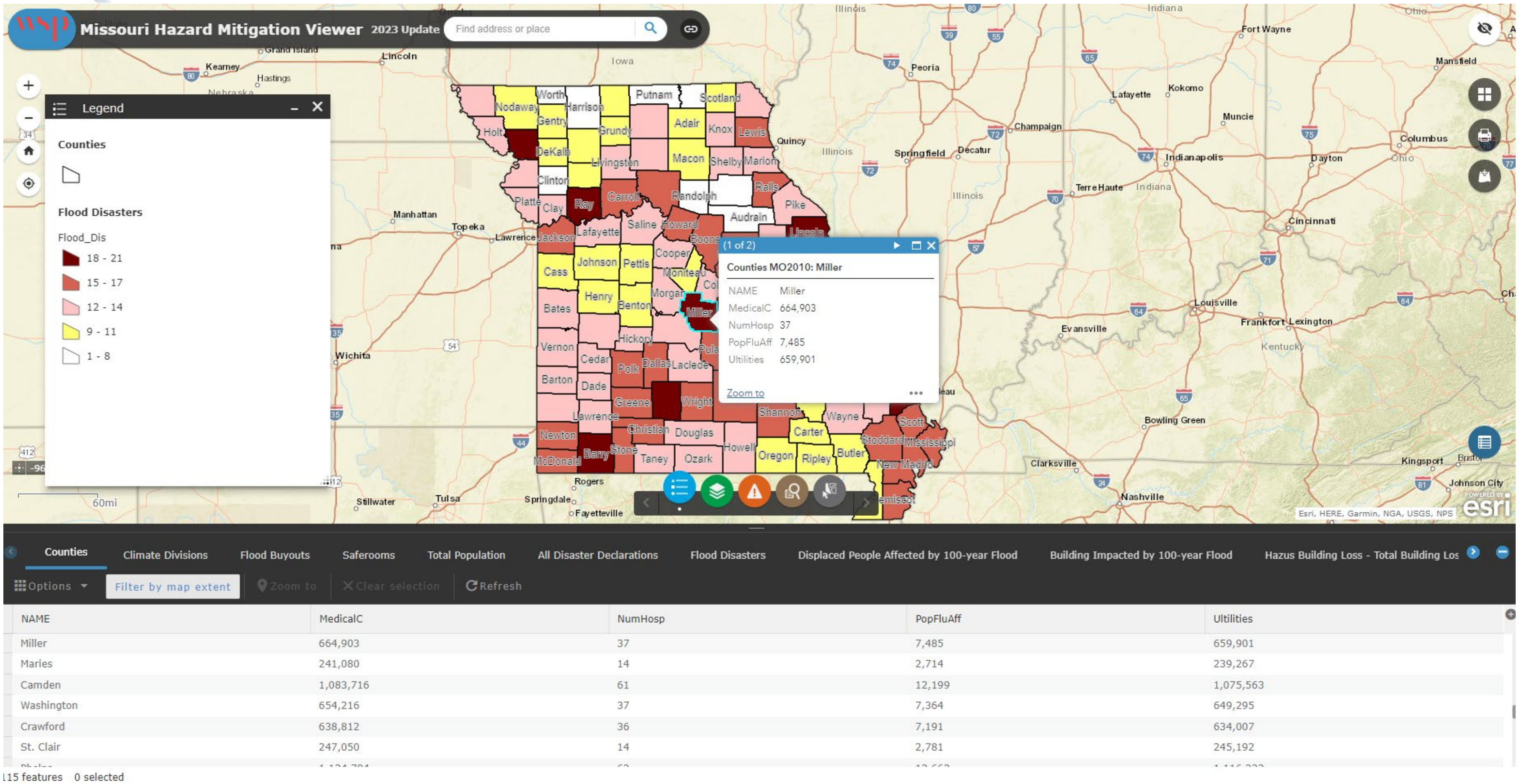
Clark 191,351 11 2,154 189,911
Atchison 160,729 9 1,809 159,520
Scotland 127,869 7 1,439 126,907
Nodaway 587,750 33 6,616 583,328
Schuyler 109,534 6 1,233 108,710
Putnam 129,575 7 1,459 128,600
115 features 0 selected

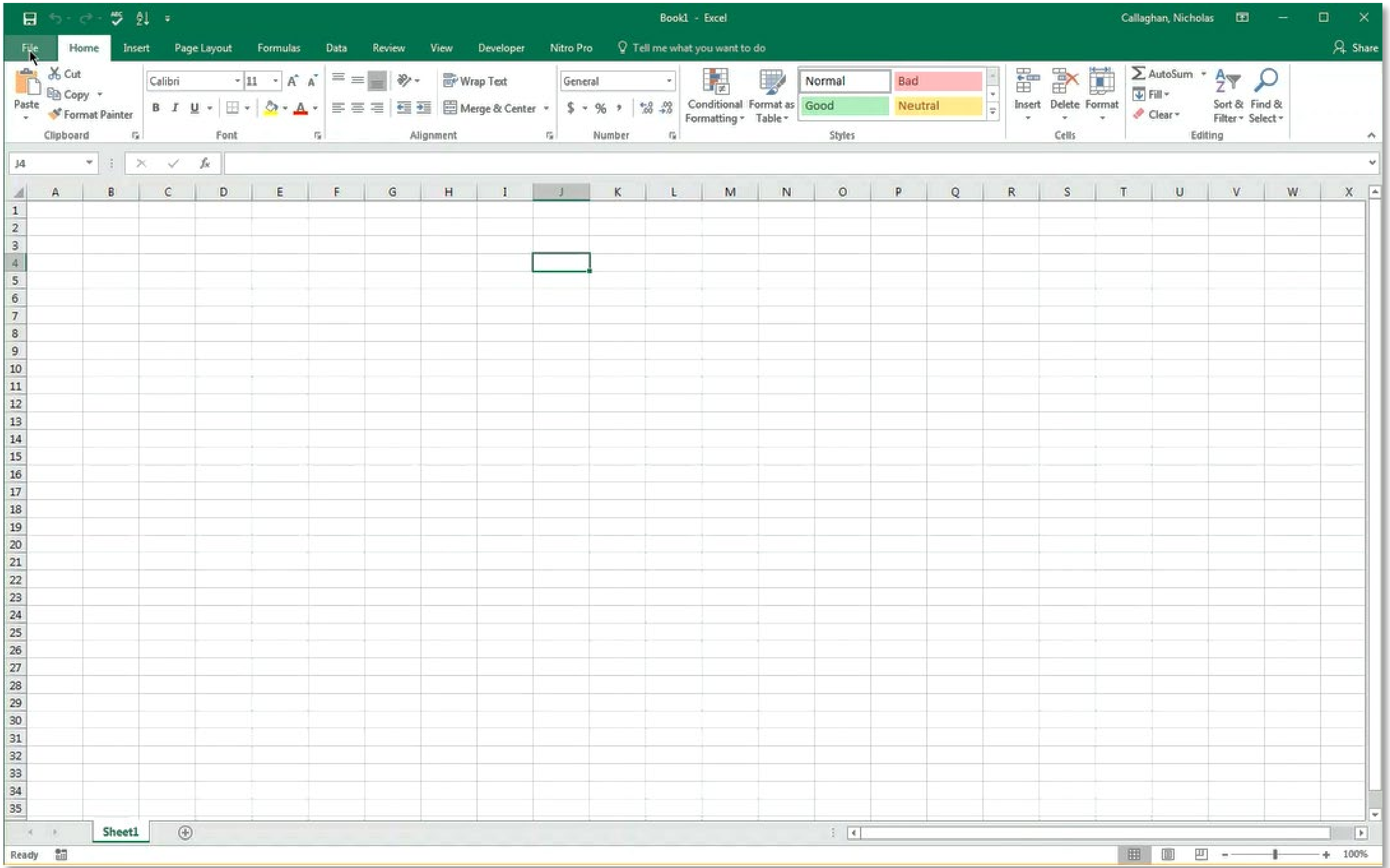


A single county or group of counties may be selected for export as well.

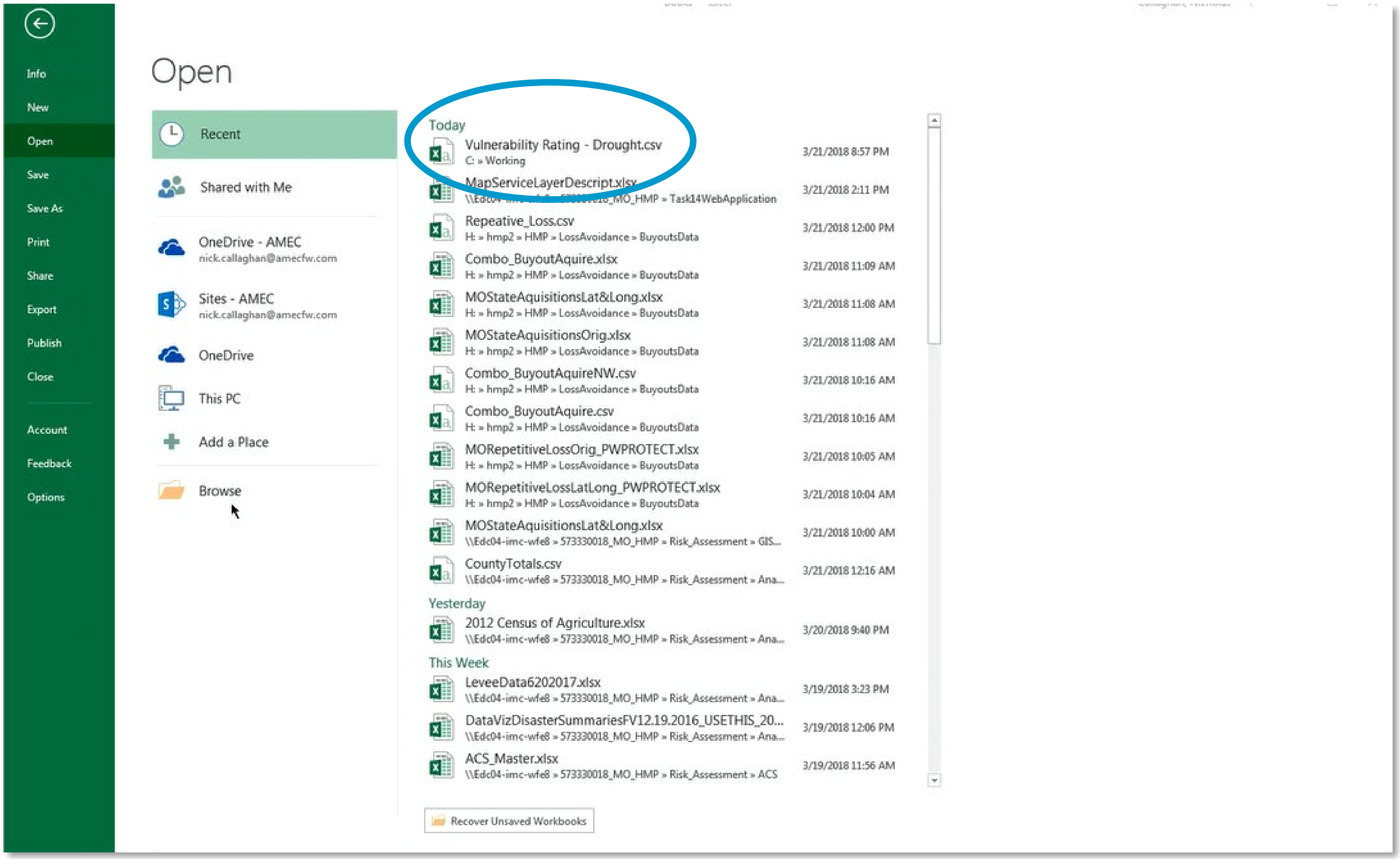
CSV Files in Excel

Downloaded CSV files can be opened in several formats as shown in detail below. To Open a CSV in Excel:

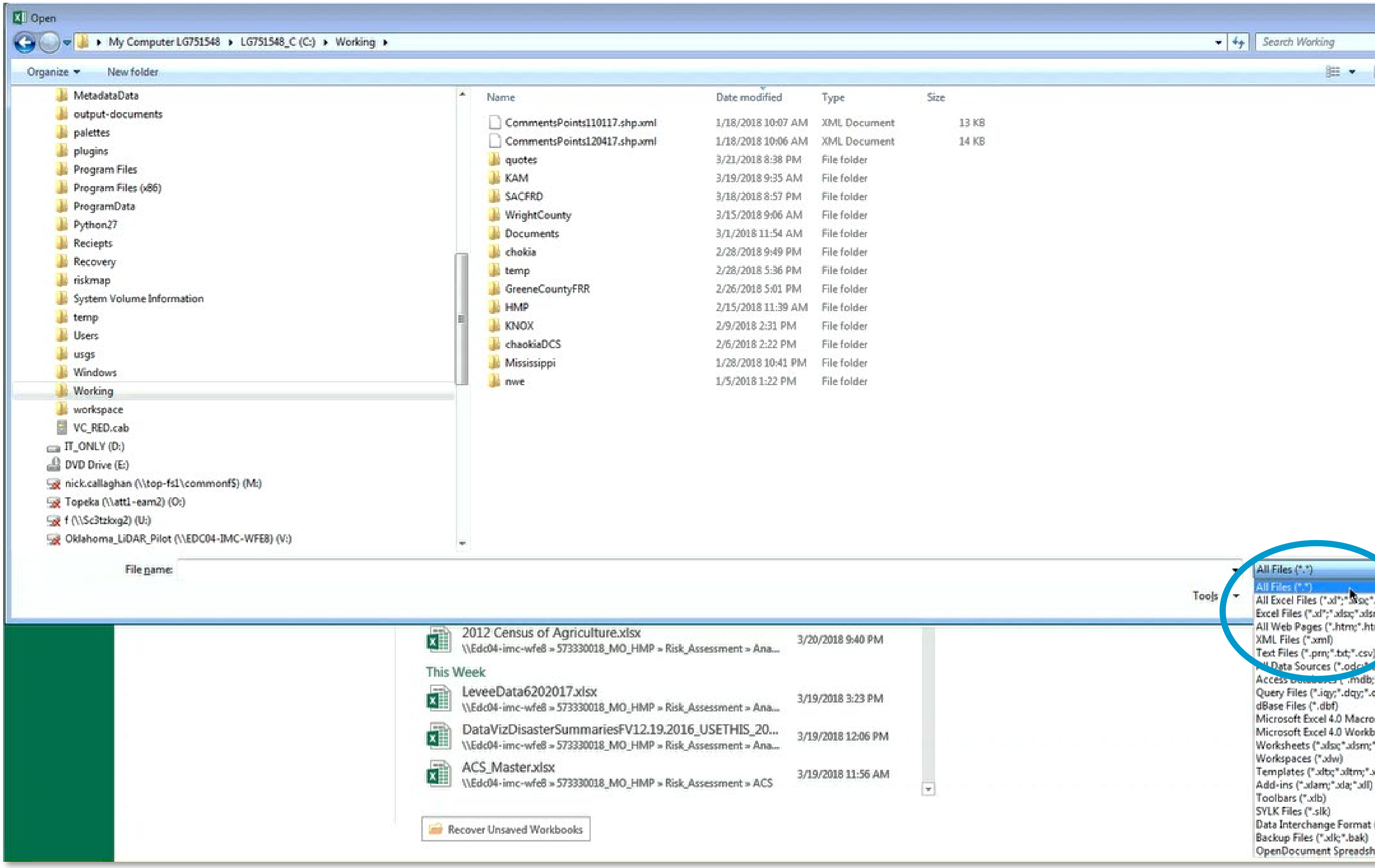
1) Open a blank Excel file.



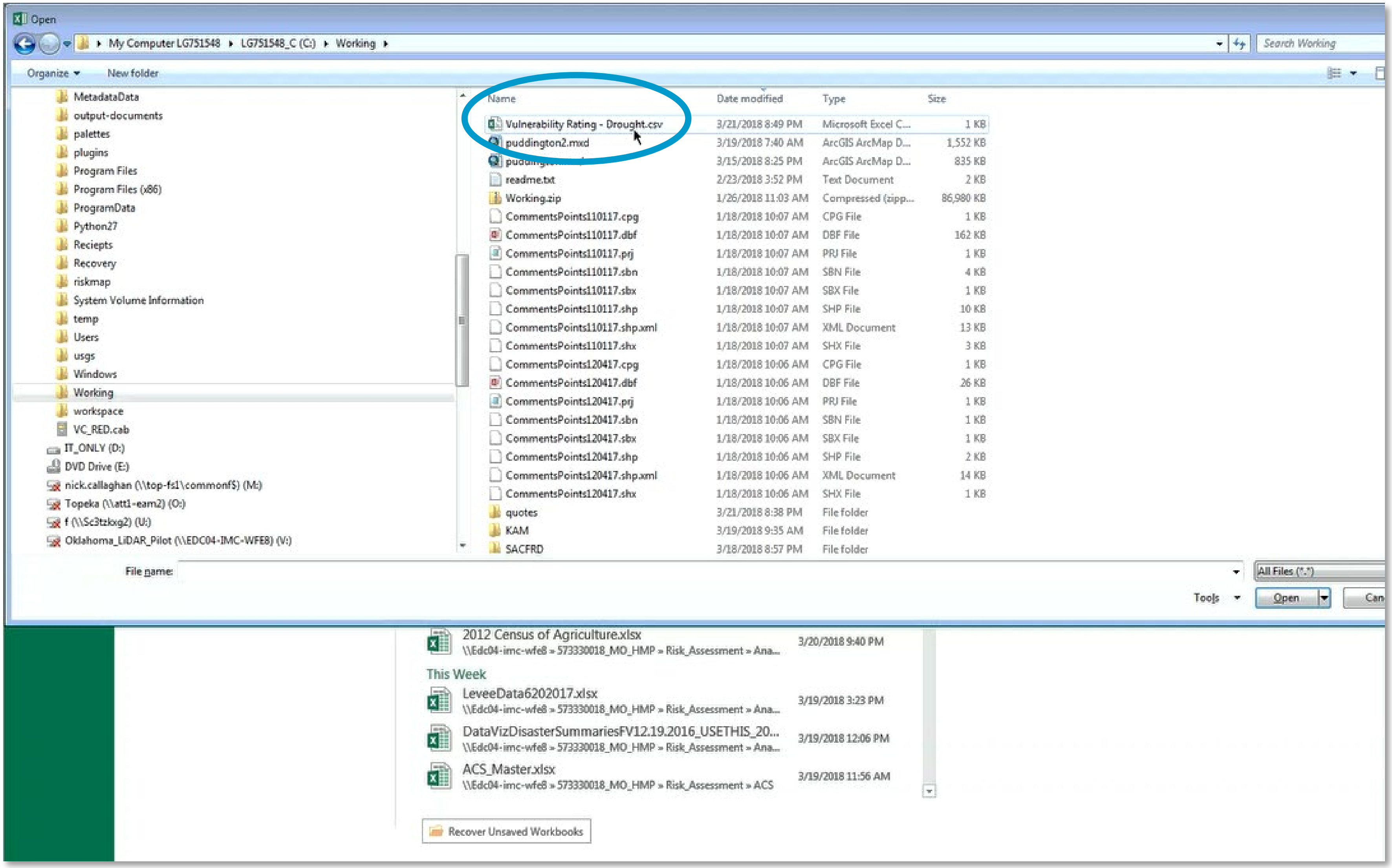
2) Click File and Browse to the CSV file



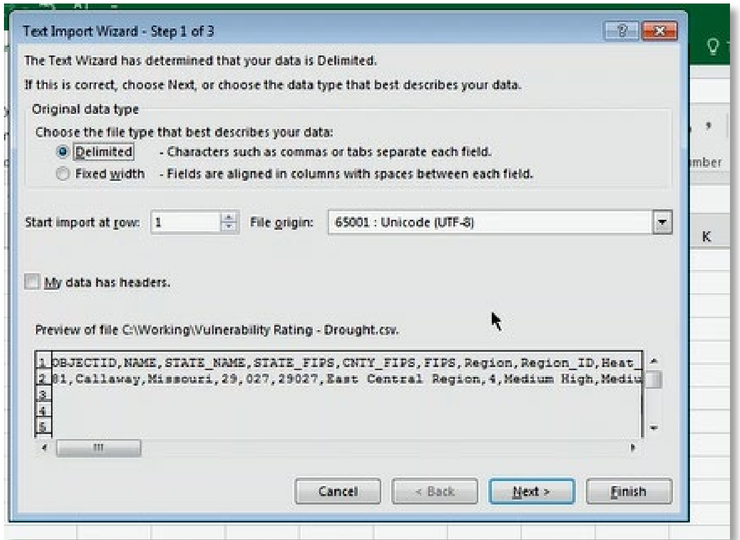
3) Navigate to the saved CSV location. Using the dropdown arrow for file types in the bottom right side of the window, choose “All Files (*.*).



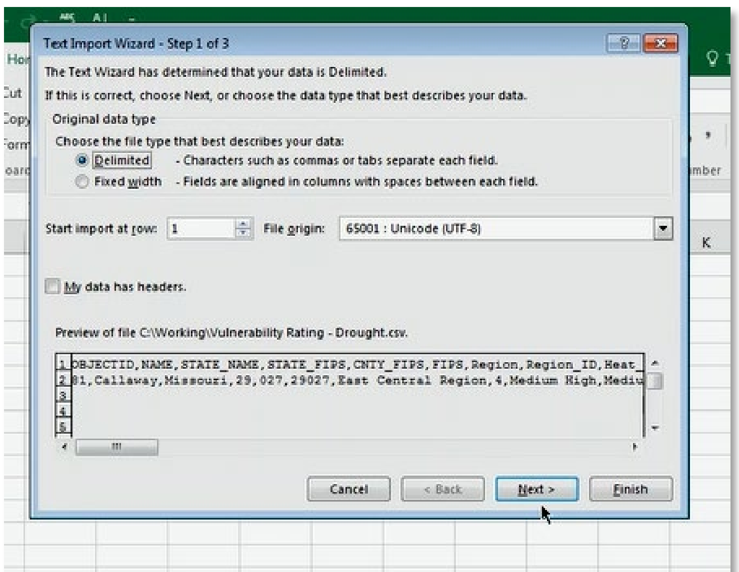
4) Click on the CSV file in the File Name window.



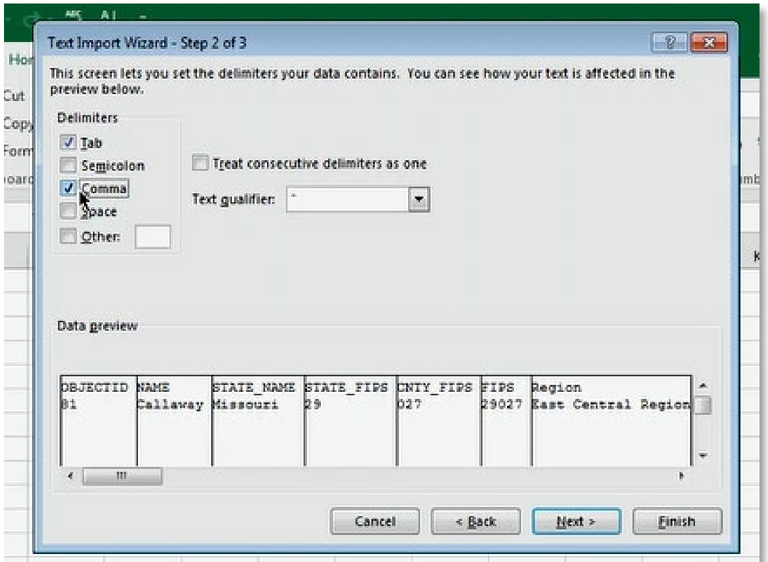
5) A Text Import Wizard window will open showing Step 1 of 3. Choose the “Delimited” radio button in the upper middle of the window.



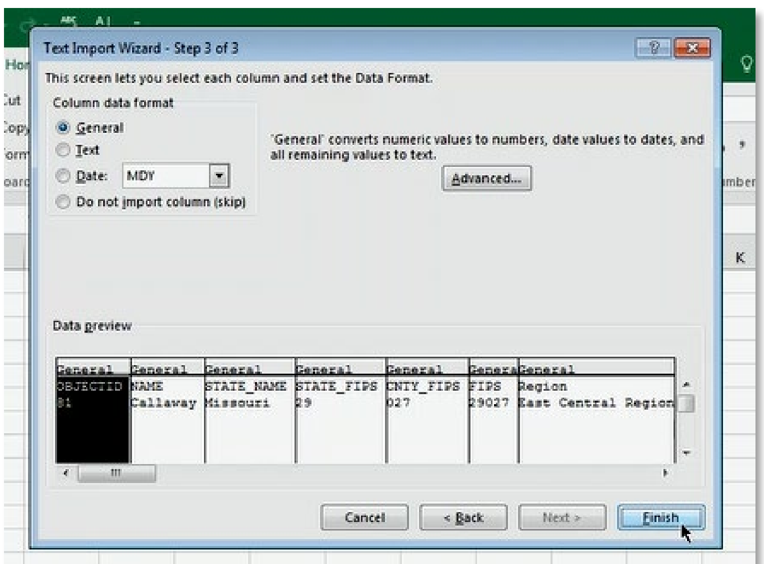
6) Then click "Next" at the bottom right.



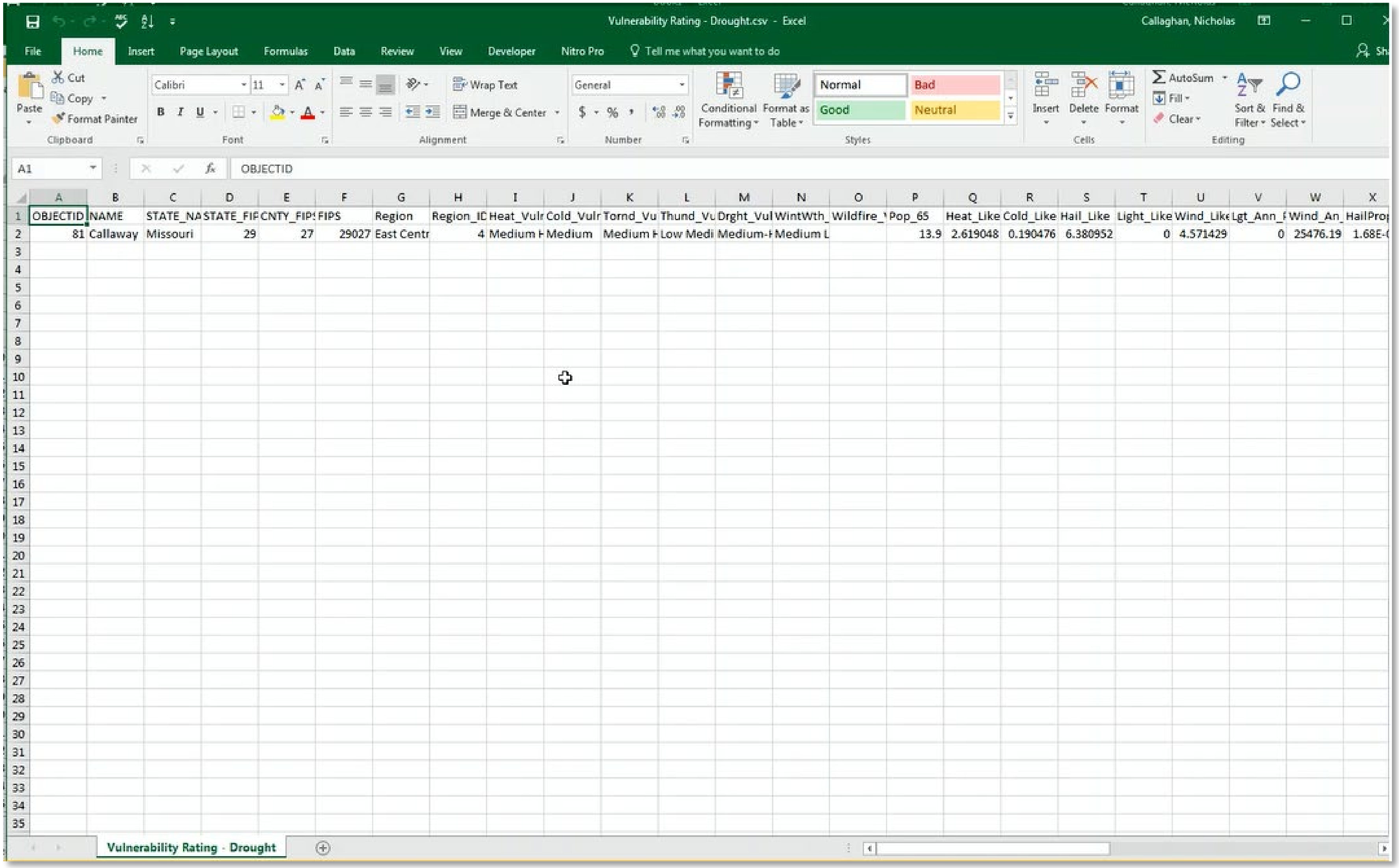
7) The Step 2 of 3 Text Import Wizard Window will open. Select the "Tab" and "Comma" check boxes on the left. Then click "Next" at the bottom.



8) The Step 3 of 3 Text Import Wizard window will open. Click the "General" radio button on the left. Then click "Finish" at the bottom.



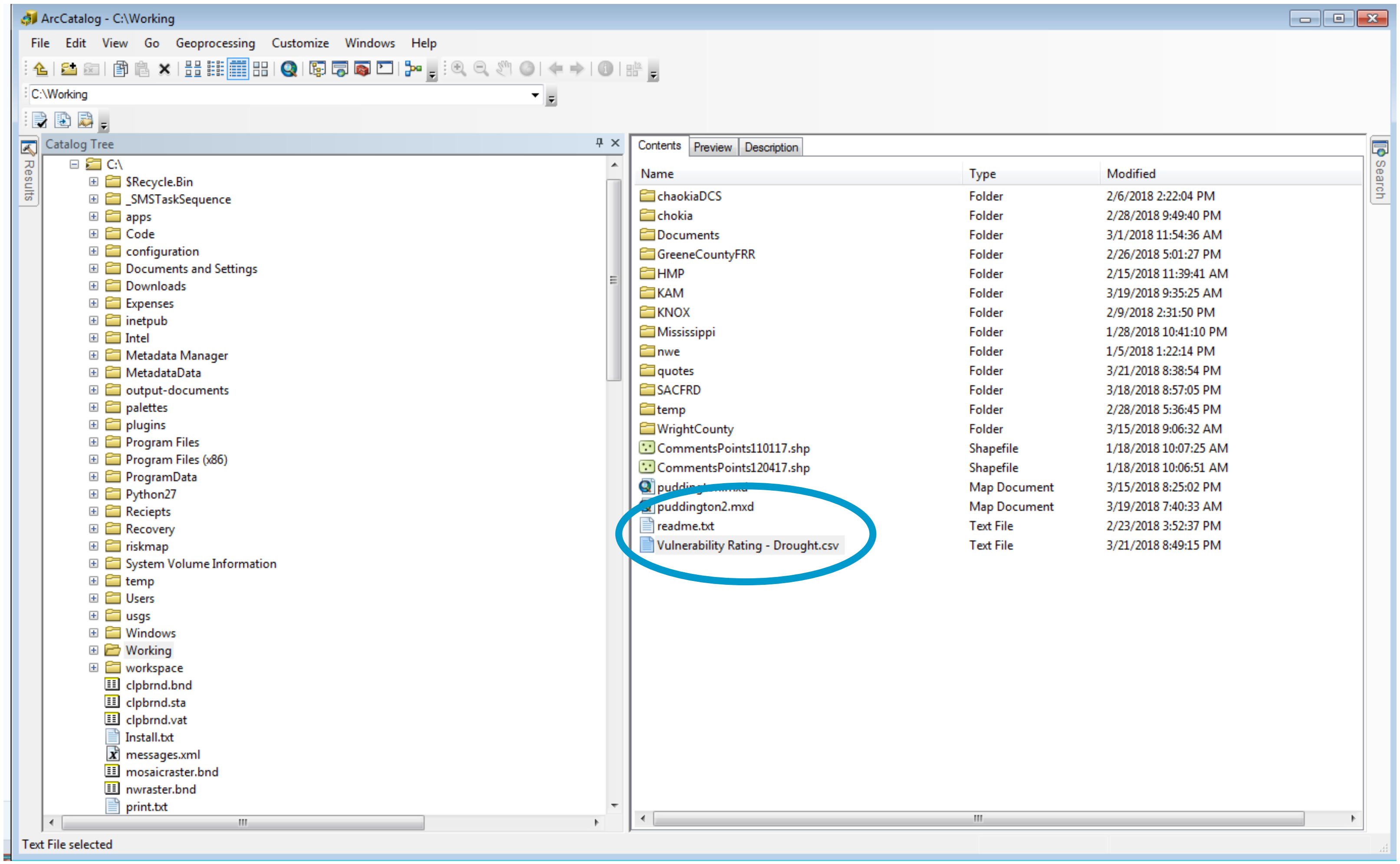
9) The Text Import Wizard window will shut and the data will appear in the Excel spreadsheet.



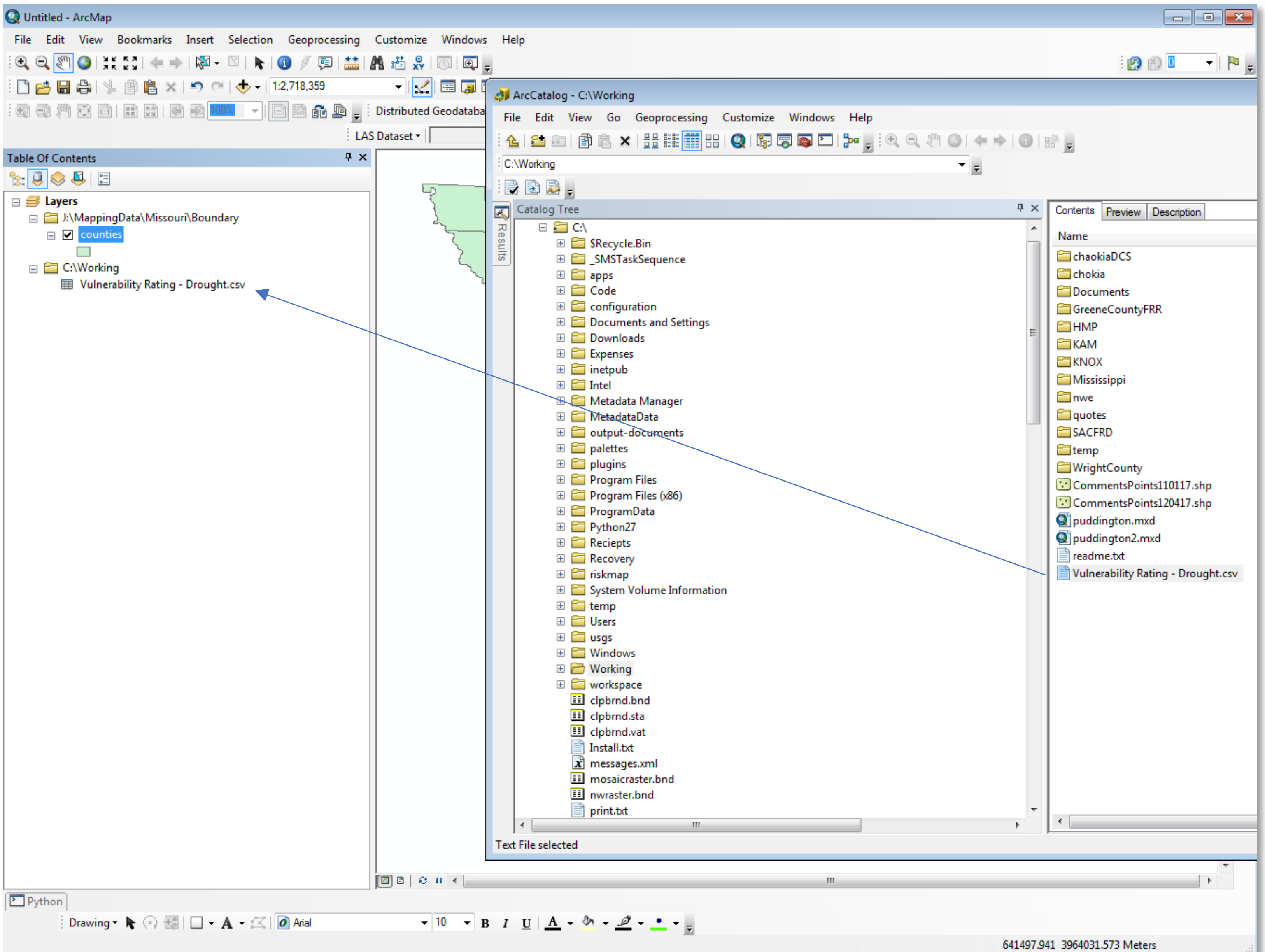
CSV Files in ArcGIS

To Open a CSV file in ArcGIS

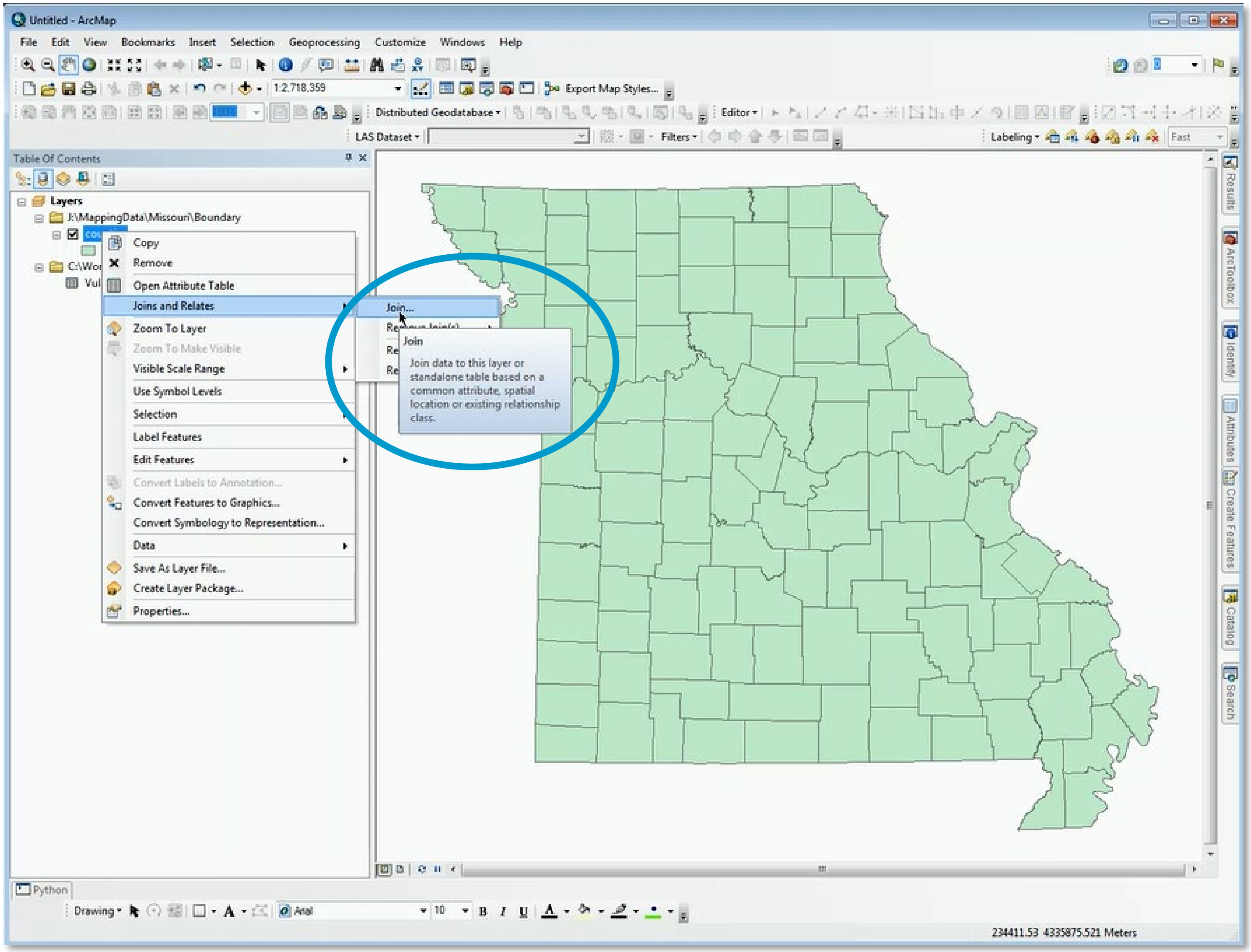
1) Open ArcMAP and then ArcCatalog. Navigate to the stored CSV file location in ArcCatalog.



2) Drag the CSV file from Catalog into ArcMAP. Also add to the ArcMap a county boundary shapefile.



3) Join the CSV file to the County Shapefile by right clicking on the County shapefile in the Table of contents window to open the options window, choosing “**Joins and Relates** “and then “**Join**”.



4) A Join Data window will open. Choose the following options utilizing the drop-down arrows:

a) Join attributes from a table

b) Choose the field of the County

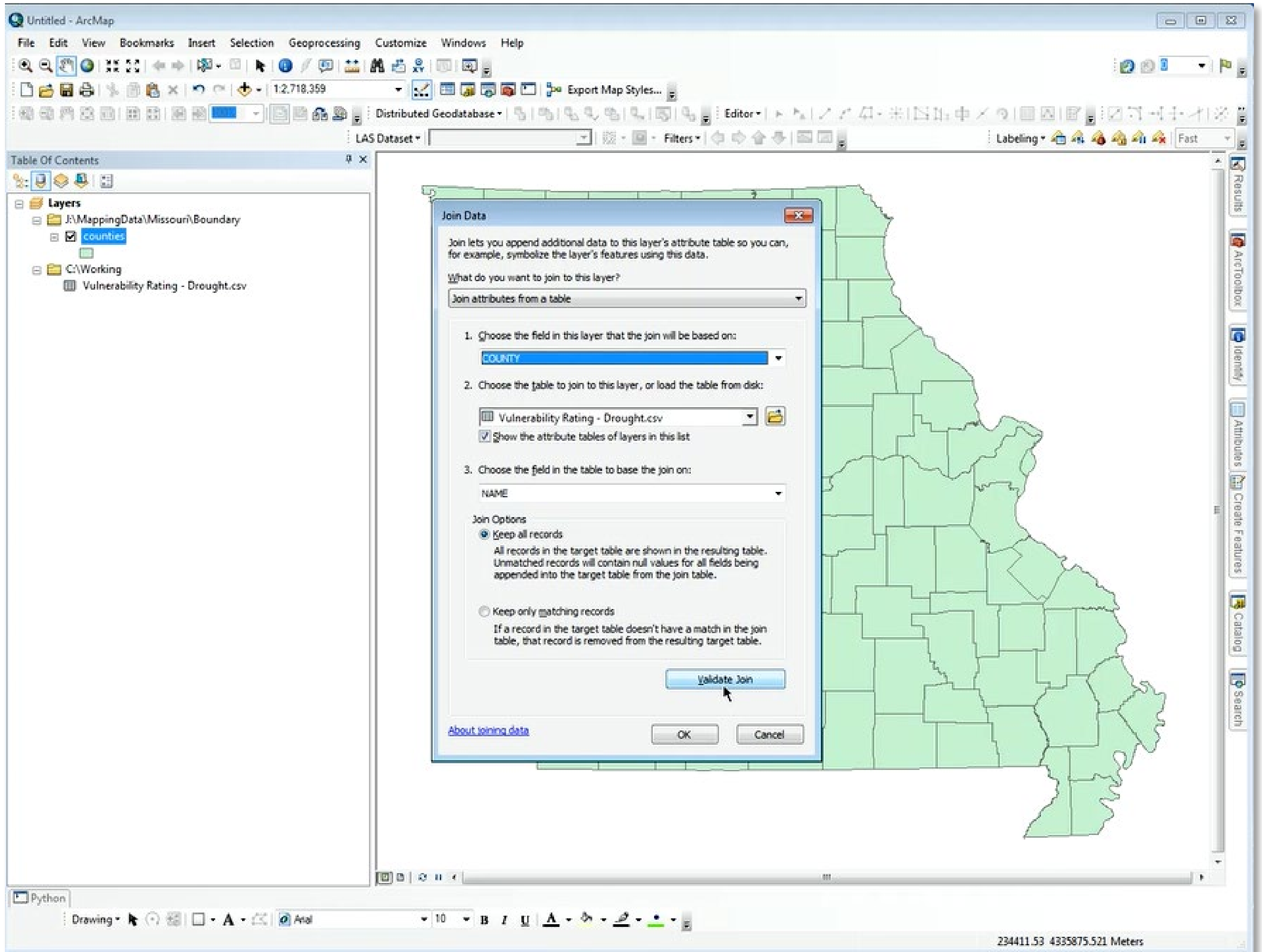
c) Choose the CSV file name

d) Choose the field with the County name in it

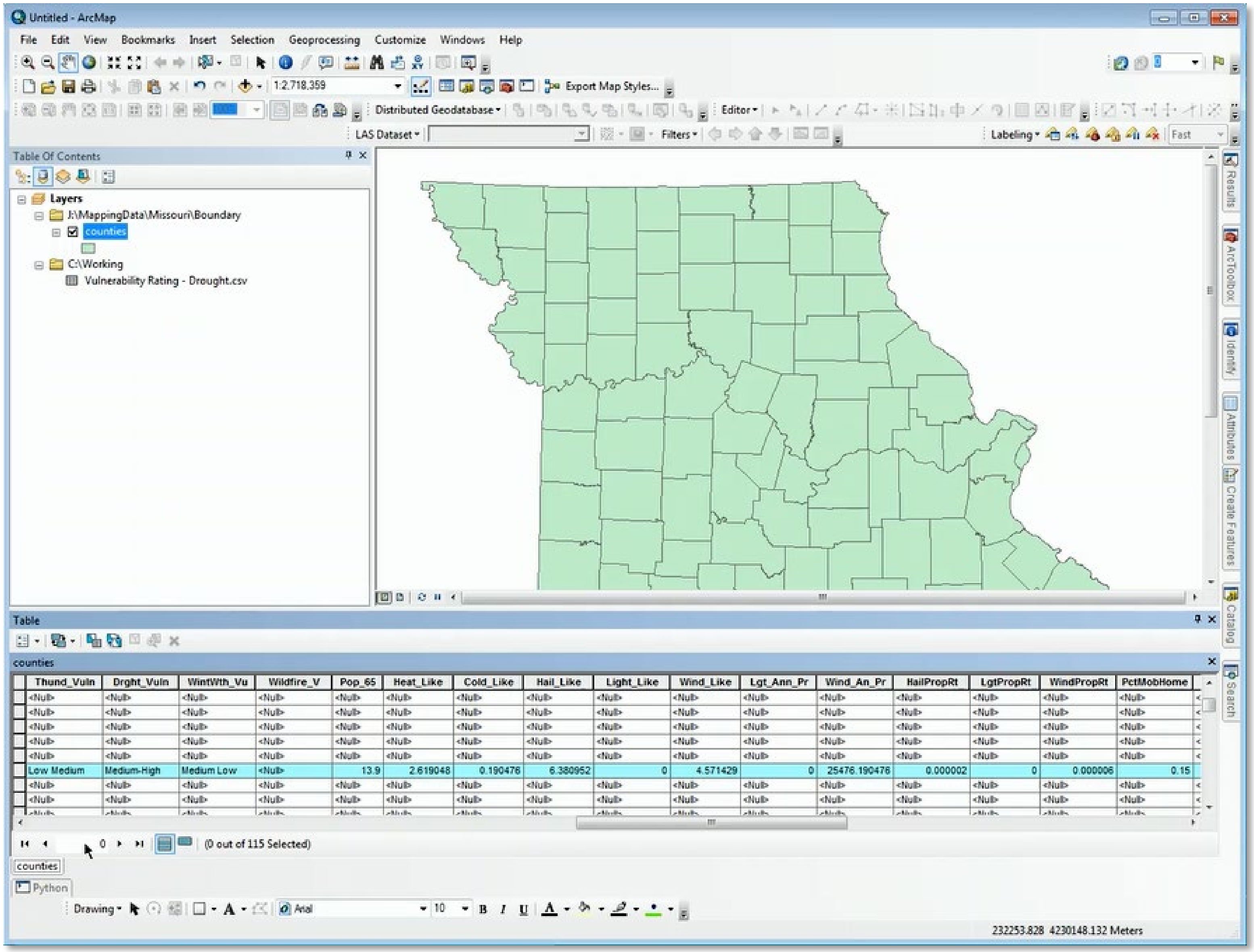
e) Choose "Keep all records"

f) Choose "Validate Join"

g) Click "Ok" at the bottom.



5) The data in the CSV file will now appear appended to the right of the County file attributes. For counties with no data in the CSV file, the attributes are <Null>.

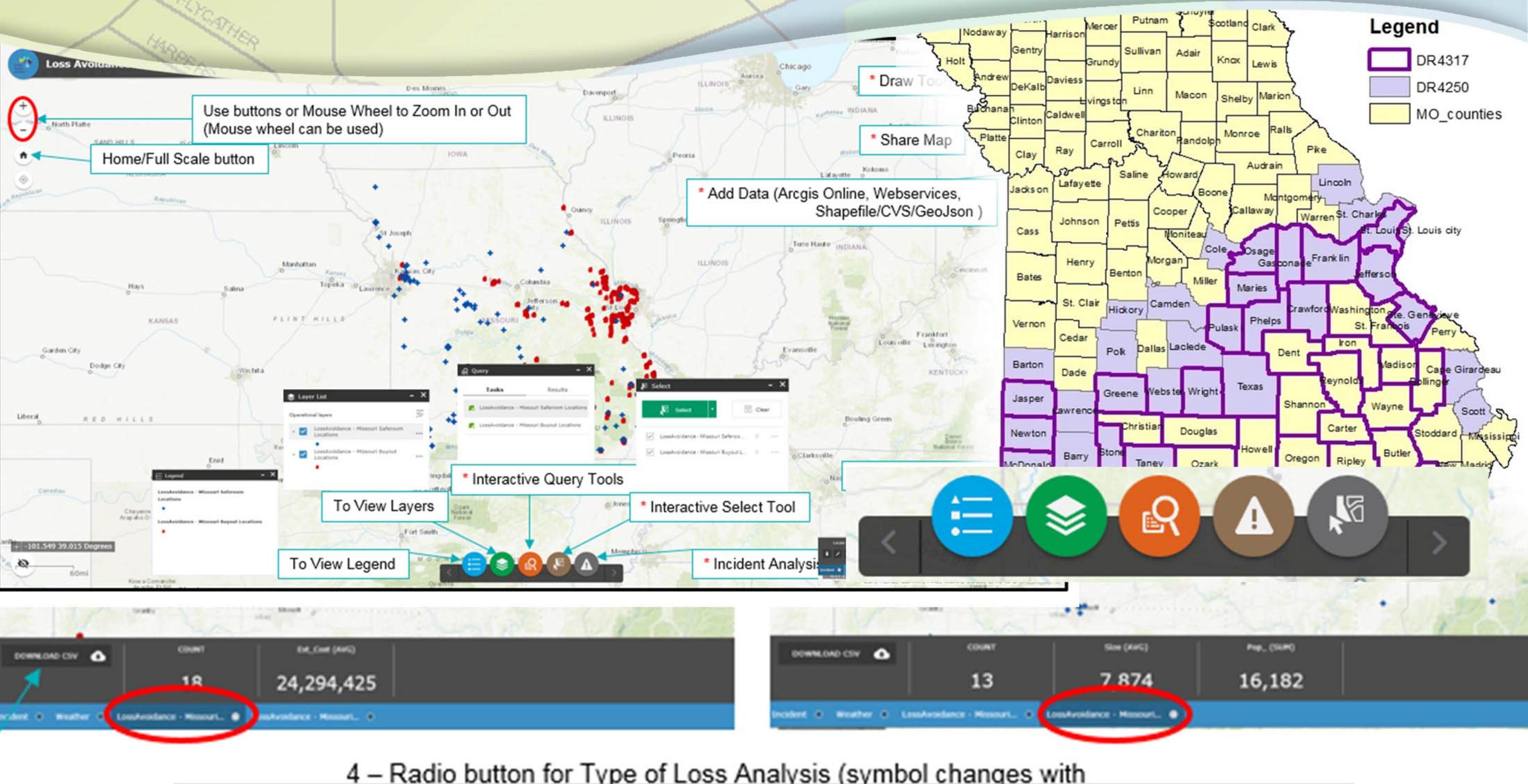


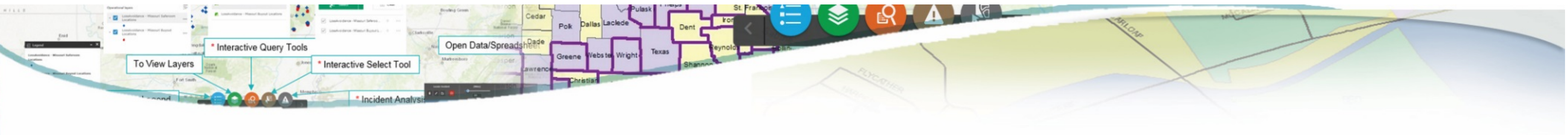
Data Key

To assist the user in analyzing the data exported and the data displayed in the Plan Document, the following Data Key has been prepared which shows the Data Category, the attribute field names, a description of the attribute fields, the methodology or source used, the Table Number, the Figure Number and the Page Numbers using this attribute in the Plan Document.

Appendix B2

Loss Avoidance Analysis Tool User Guide





Introduction

Following a hazard event, SEMA mitigation staff query local officials to document how mitigation actions instituted in the affected areas reduced the amount of damage or loss of life that could have resulted from an event. SEMA has updated this query process and formalized loss avoidance documentation through a newly-developed web-based tool which follows the loss avoidance methodology developed by FEMA.

FEMA developed the loss avoidance methodology to evaluate the effectiveness of mitigation projects based on the analysis of actual events. This methodology can be applied to the mitigation of any type of natural hazard. Losses avoided are determined by comparing the damage that would likely have been caused by the same storms without the project (Mitigation Project Absent, MP_A) with damage that actually occurred with the project in place (Mitigation Project Complete, MP_C). There are three phases of the general methodology for loss avoidance studies:

1) Initial Project Selection
2) Project Effectiveness Analysis
3) Loss Estimation Analysis

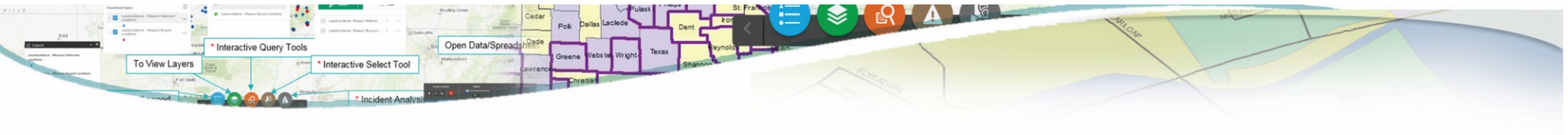
Table of Contents

Phase 1 focuses on the selection of the completed project area to be included in the loss avoidance study. Structures are screened based on the availability of data required for completion of the study. This includes actual project costs, construction completion dates, first floor elevations, structure location information, and structure information, including the type, basement information, number of floors, square footage, and building replacement value. Structures with adequate data advance to Phase 2.

Phase 2 includes a storm event analysis, to determine whether a post-construction storm event is severe enough to have caused damage if the project had not been completed (MP_A scenario), and a hazard analysis, to determine the impact of the hazard event (e.g., depth of flooding) at the mitigation project location.

Phase 3 includes two steps. First, an economic evaluation of the project scope is completed for both the MP_A and MP_C scenarios for each hazard event analyzed. The difference between the total losses for the two scenarios is calculated and losses avoided are determined. Second, the return on investment (ROI) is assessed by comparing the losses avoided to the total project investment.

For the 2018 State Plan Update, SEMA has developed a web-based, loss avoidance analysis tool (LAAT) to assist SEMA staff and local officials to collect and store the data necessary to complete a loss avoidance study following a hazard event.



Loss Avoidance Analysis Tool (LAAT) Overview

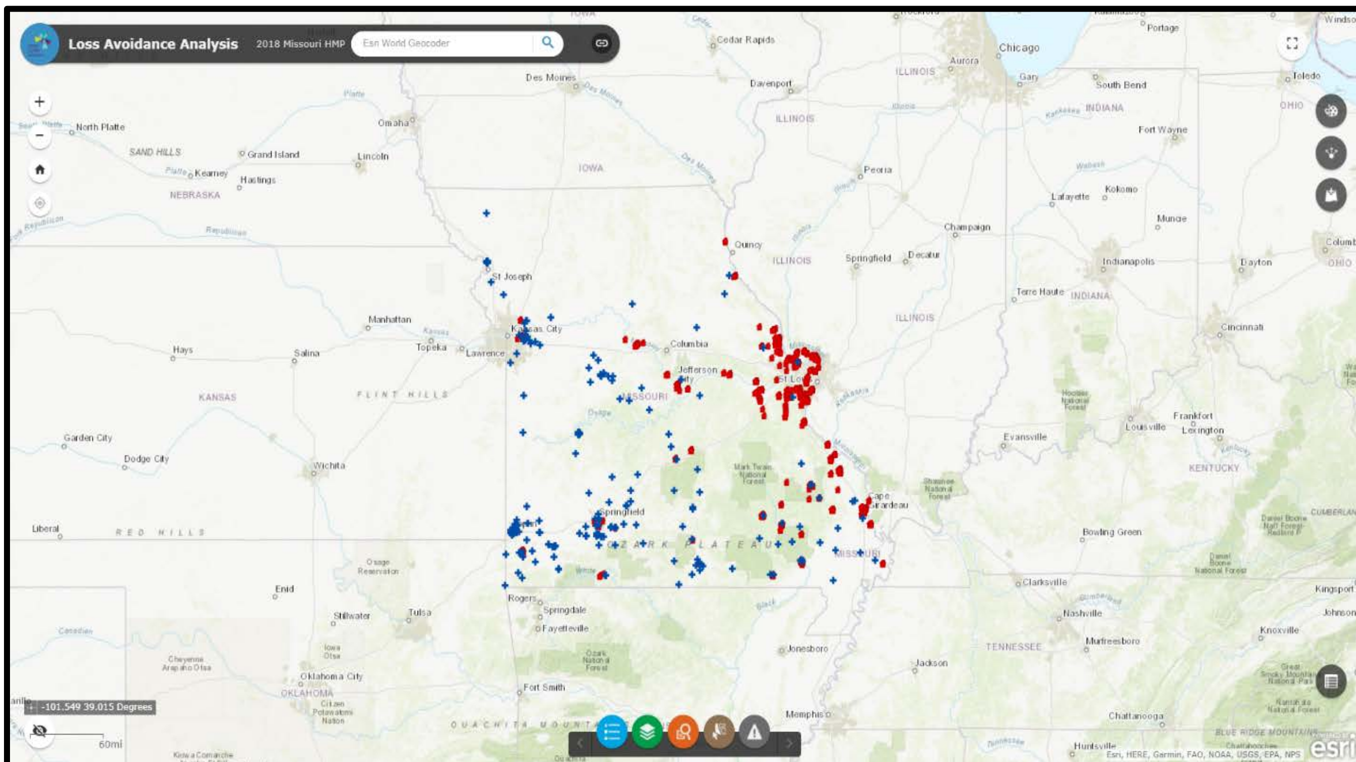
The web-based, loss avoidance analysis tool (LAAT) is a database of the structural data necessary to complete Phase 1 of a loss avoidance study and is a data collection tool for the storm event data necessary to complete Phase 2 of a loss avoidance study. This is currently for tornado Saferooms and flood buyouts locations. The LAAT website can be accessed here: http://bit.ly/SEMA_LossAvoidance.

Step 1

Step 1: Initial Project Selection – For all completed mitigation projects for Buyout and Saferoom projects within the State, the LAAT database has been populated with project details as included in the approved grant application and project closeout documents. This includes actual project costs, construction completion dates, first floor elevations, and structure information where it was available. Not all locations have all the information. The FEMA Corps improved the latitude and longitude data for each acquisition site, at the time of the 2018 State Mitigation Plan Update. This data has been incorporated into the LAAT. **Figure 1** presents the LAAT website showing the tornado safe room locations in blue and residential buyout locations in red.

Figure 1. Loss Avoidance Analysis Tool (LAAT) Website

Each mitigation project has also been spatially located based upon the street address or latitude/longitude, as either obtained from the project grant application or field located with GPS. Efforts to map completed buyouts prior to 2002 have proven difficult because communities have combined parcels and lots into combined open spaces, streets and addresses no longer exist (as a result of the buyouts).



Those mitigation projects with limited structural or location data are included in the LAAT database, but should move forward to Phase 2 with an understanding of the known deficits before being utilized in a loss avoidance study.

The LAAT database may be updated at any time to include additional project information. For future mitigation projects, the structure data necessary to complete Phase 1 of a loss avoidance study will be entered by SEMA staff upon project completion and closeout.

Step 2

Step 2: Project Effectiveness Analysis – Because a loss avoidance study measures benefits of a completed project based upon an actual event, the local official will be tasked with completing the storm event data collection form following a hazard event within their community or SEMA staff can add this information easily to any reports resulting from disaster declarations. The user can spatially select those mitigation projects within the hazard event area and do a simple export to show the calculated loss avoidance. **Figure 2** displays the Operational Tools available on the website. **Figure 3** shows the Add Data Tool options. Users can either upload a project area shapefile or simple draw an area of interest to use for the analysis as shown in **Figure 7**, respectively. The user can also share the data from the analysis with others as shown in **Figure 5**.

Figure 2. LAAT Website – Operational Tools

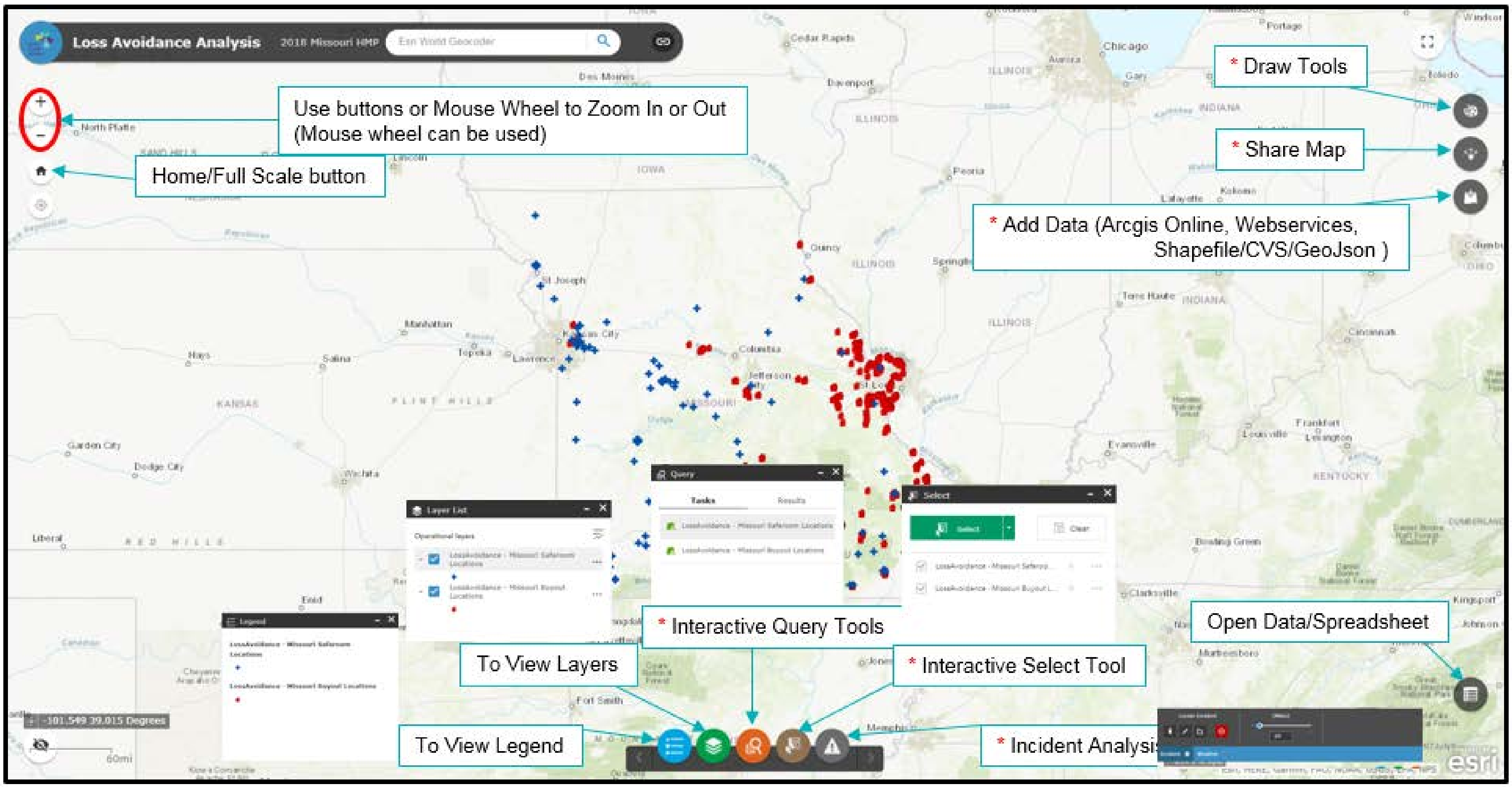
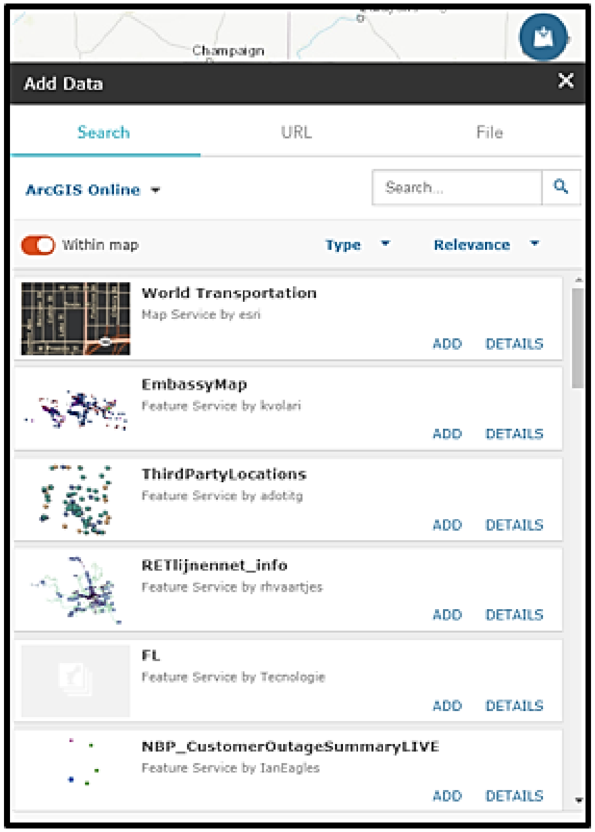


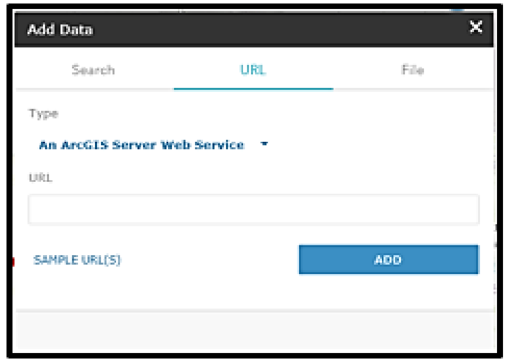
Figure 3. LAAT Website – "Add Data" Tool

1) From ArcGIS Online

2) From another Public Location/Agency

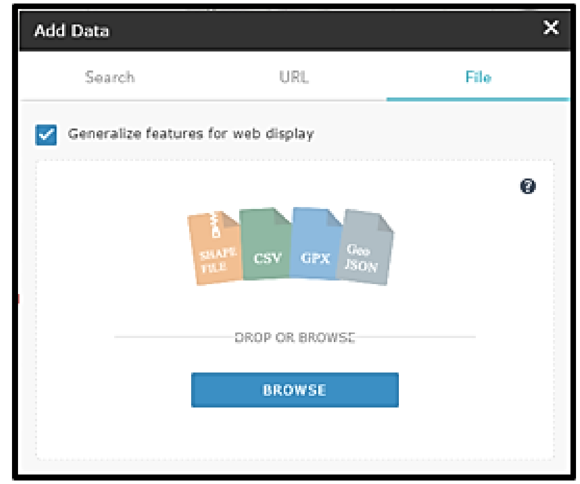
3) Project and/or Personal Data





Add Data from following:

- ArcGIS Server Web Service
- WMS OGC Web Service
- KML
- GeoRSS File
- CSV File



Add Data from Local Computer by Drag/Drop or Browse to Location.

Files Include:

- Shapefile
- CSV
- GPX
- GeoJson

Figure 4. LAAT Website – "Draw" Tool

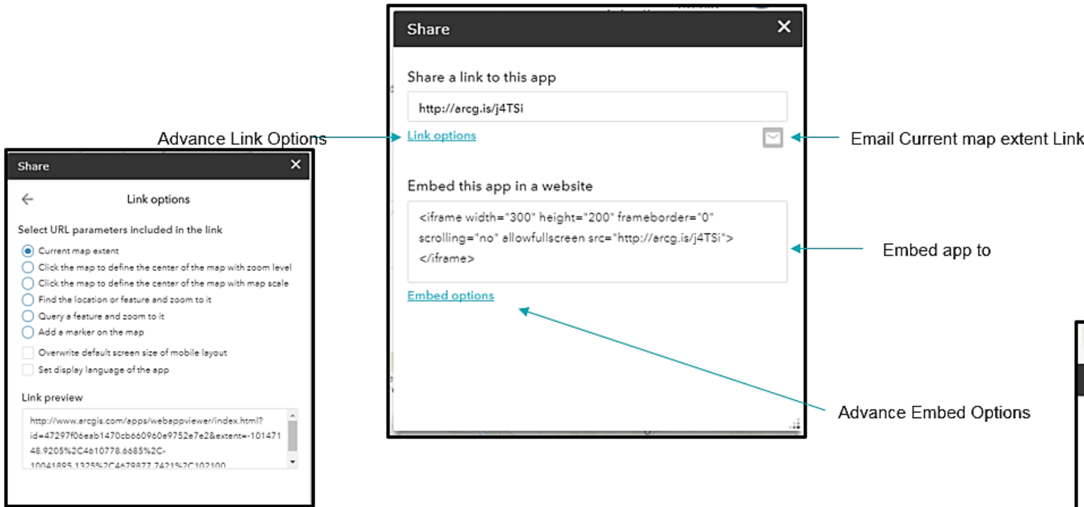
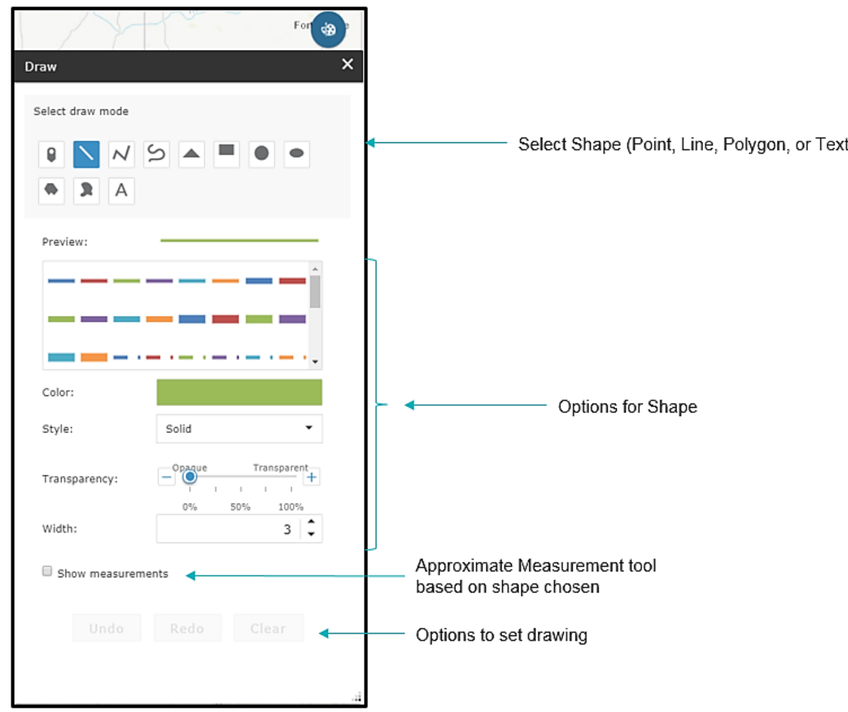


Figure 5. LAAT Website – "Share" Tool

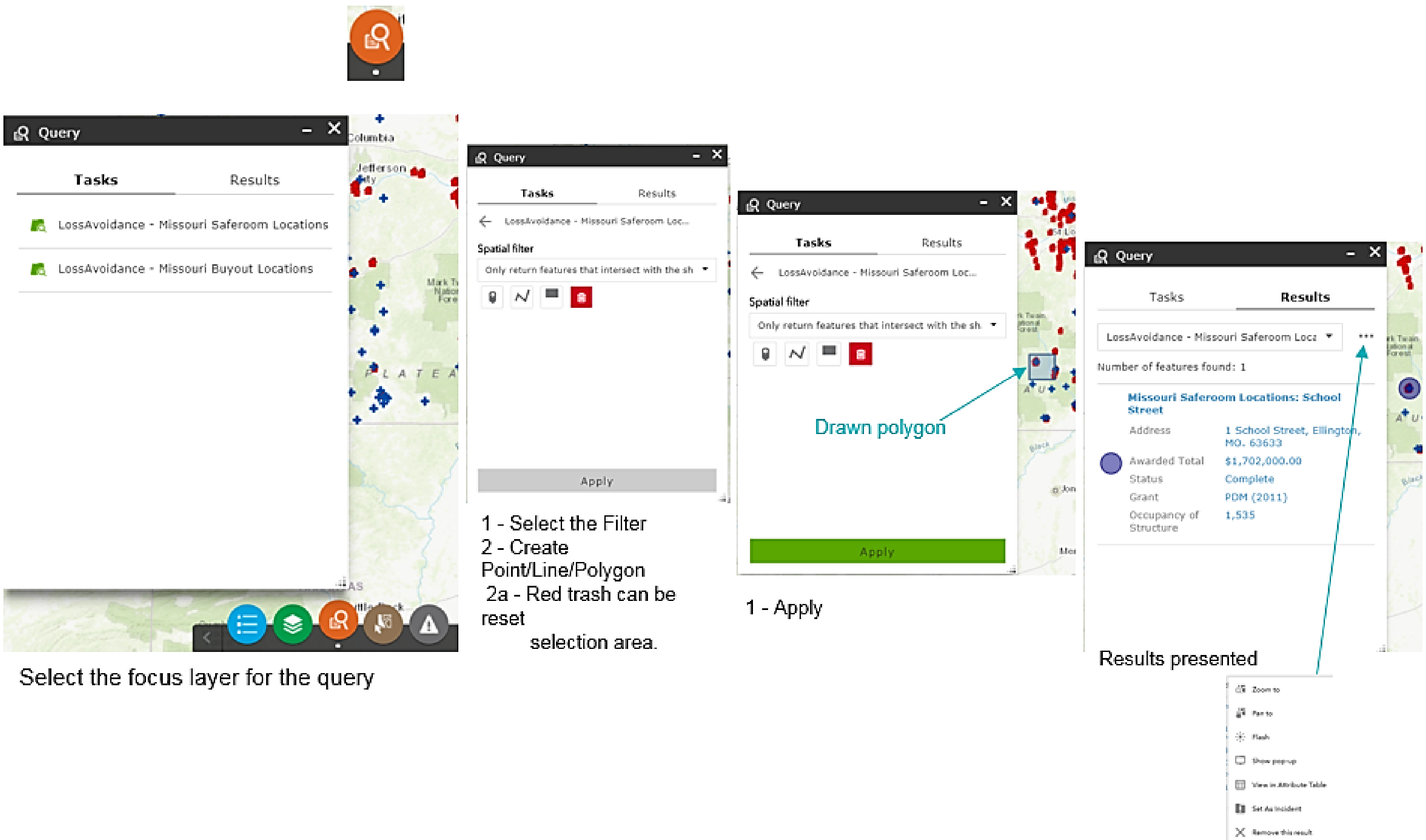


Step 3

Step 3: Loss Estimation Analysis - This final phase consists of estimating losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. The two major tasks in Phase 3 are (1) calculating losses avoided and (2) calculating the return on investment. This can now be done "on the fly" with the LAT by utilizing the Query Tool as shown in **Figure 6**.

This information and the results of completed loss avoidance studies will be incorporated into mitigation success stories to aid in the assessment of the current and future goals, objectives, and actions by simply exporting the data in the needed format using the Incident Analysis Tool shown in **Figure 7**.

Figure 6. LAAT Website – "Query" Tool



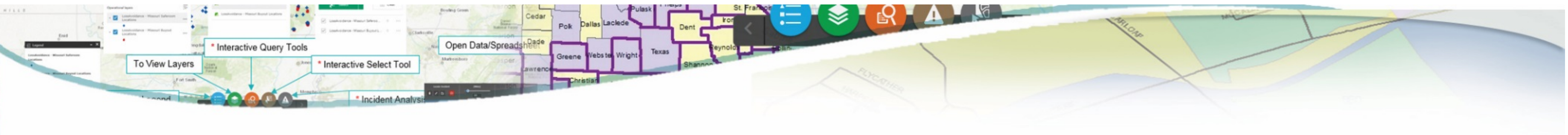
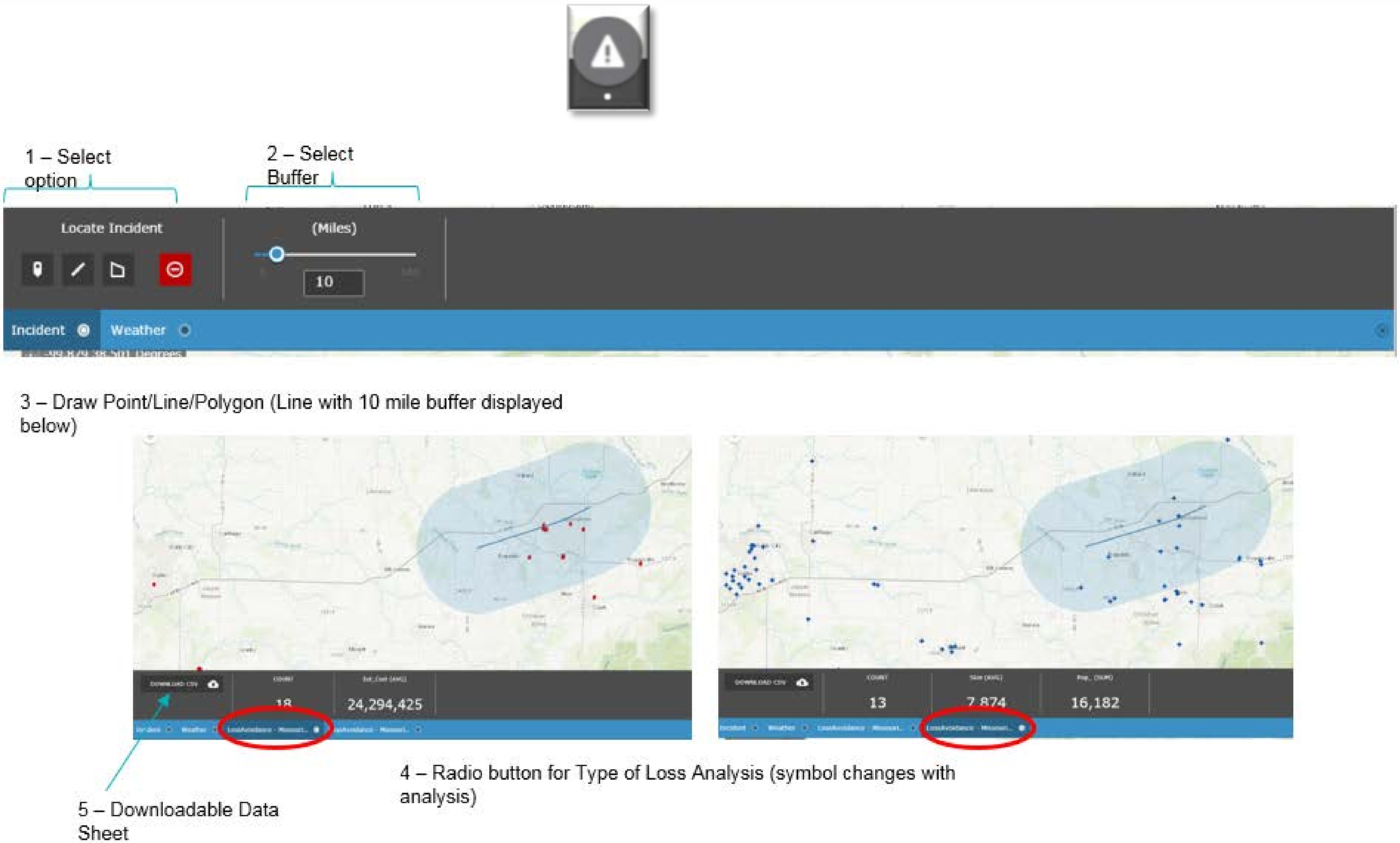


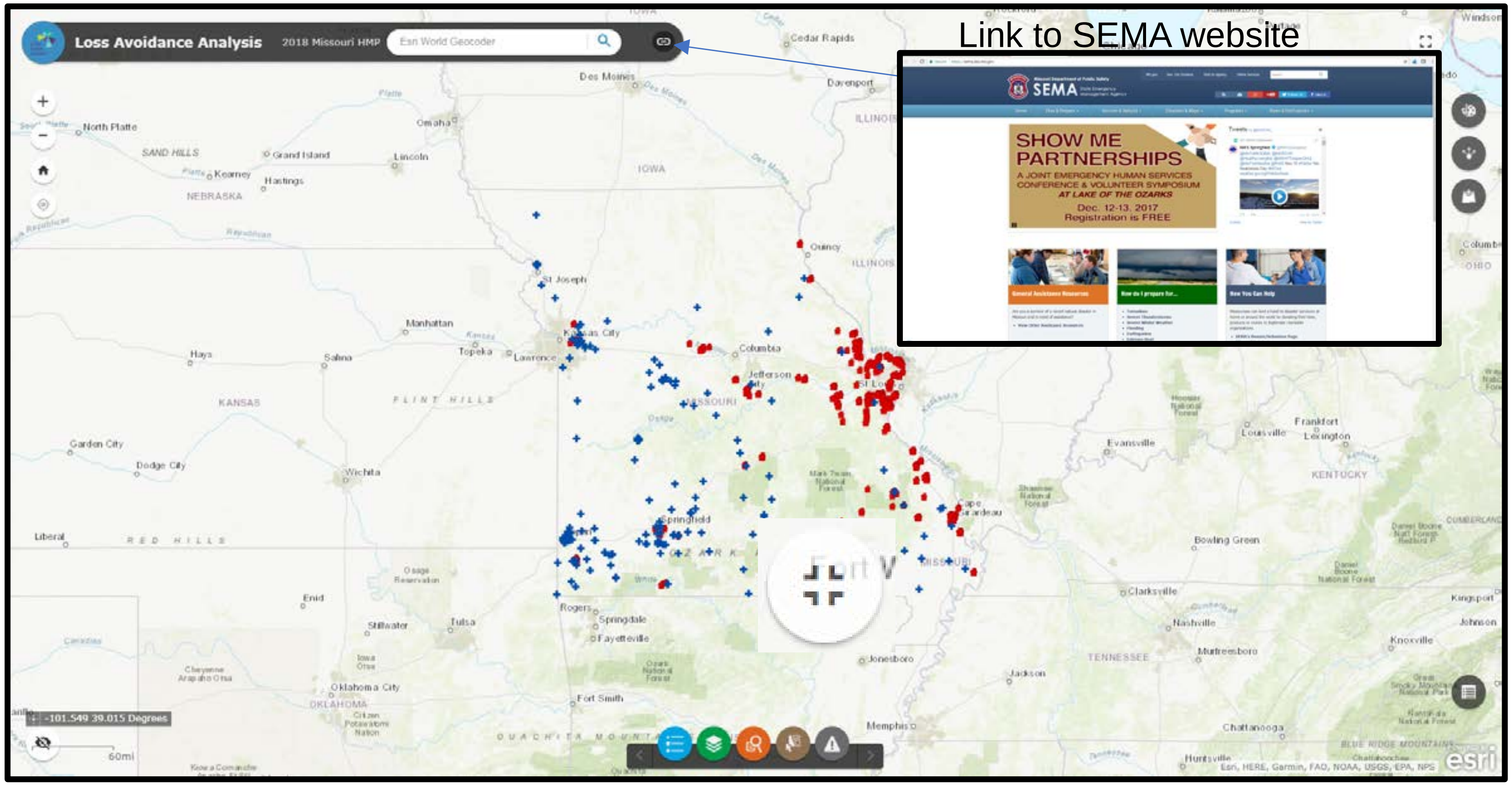
Figure 7. LAAT Website – "Incident Analysis" Tool



The initial screen looks like this. The chain link in the top banner is a link to the SEMA website.

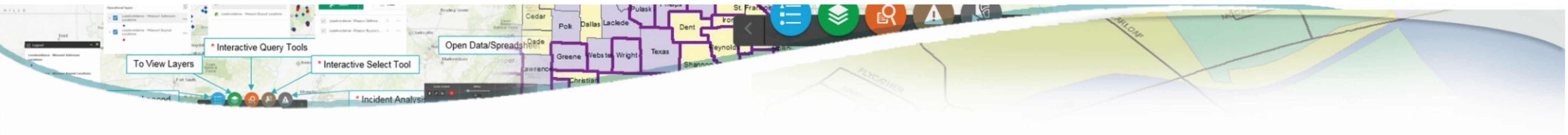
Use the + and – buttons in the upper left of the screen or the Mouse wheel to zoom in and out.

The Home or Full Scale button will zoom to the state and center it in the screen.



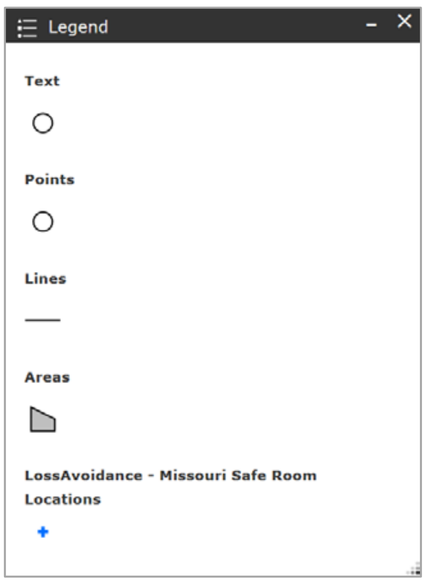
Use the Full Screen button in the upper right of the screen to make the website take up the entire screen on the window. When activated it changes to look like the button on the right. It is a toggle, so click it again to go back to normal screen.

The Attribute button in the bottom right of the screen can be clicked to view the attributes associated with the layers in the map.

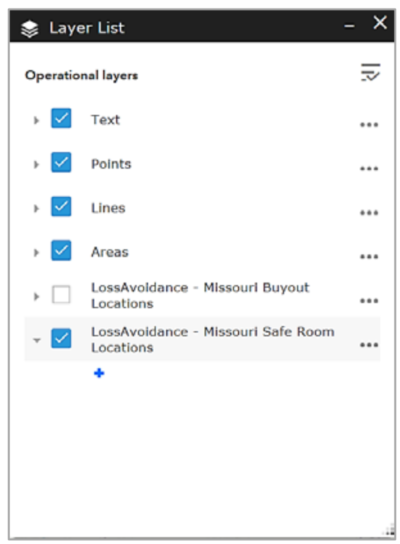


At the bottom of the page is a banner with five tool icons. From left to right they are the Legend, the Layer List, the Query, the Incident Analysis and the Select tools. The following pages describes each icon.

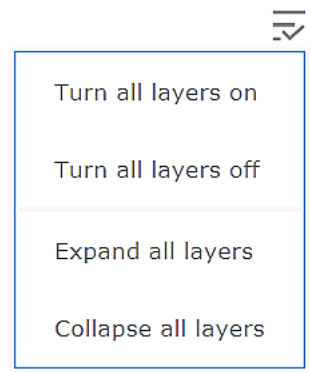
The blue one is the Legend icon. Clicking it will open a window explaining the symbology (symbols and color) of the active layers.



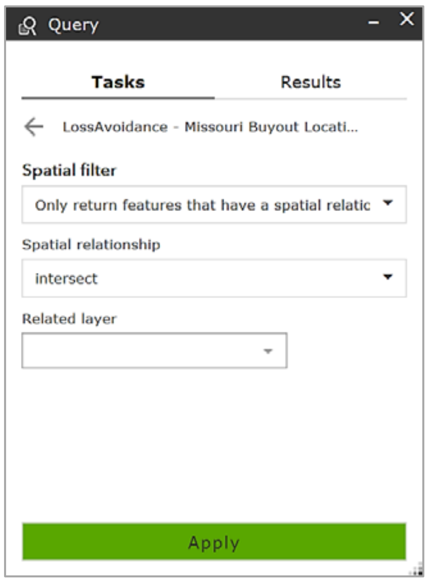
The green one is the Layers List. Clicking it will open a window indicating what Operational layers are in the map. The blue check marks indicate the layer is turned on, the empty checkbox indicates they are turned off. These are toggles and the layers can be easily activated/deactivated by clicking inside the checkboxes.



This icon in the upper right of the Layer List, when clicked will open to show options to turn on/off all layers and expand/collapse all layers.

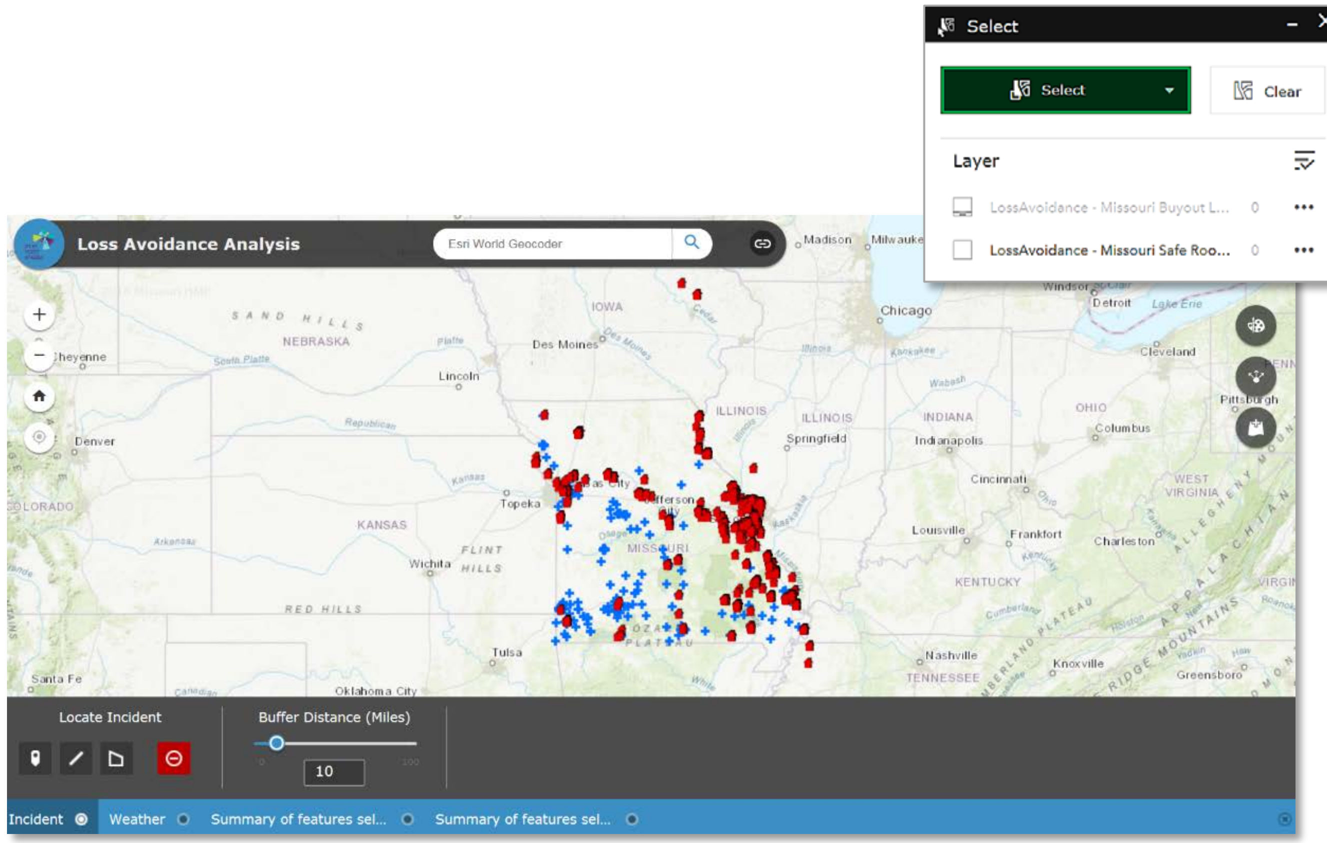


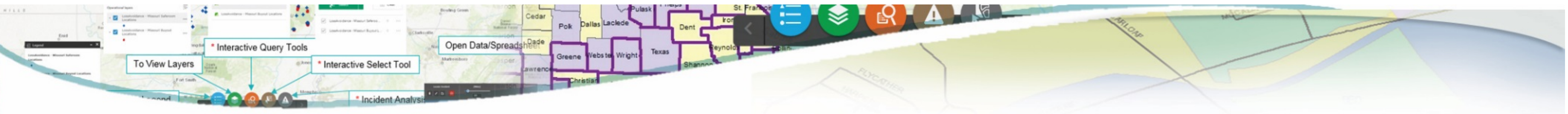
The orange one is the Query Tool. Clicking it will open a window to use in User Analysis. This functionality will be described more in Example #1 below.



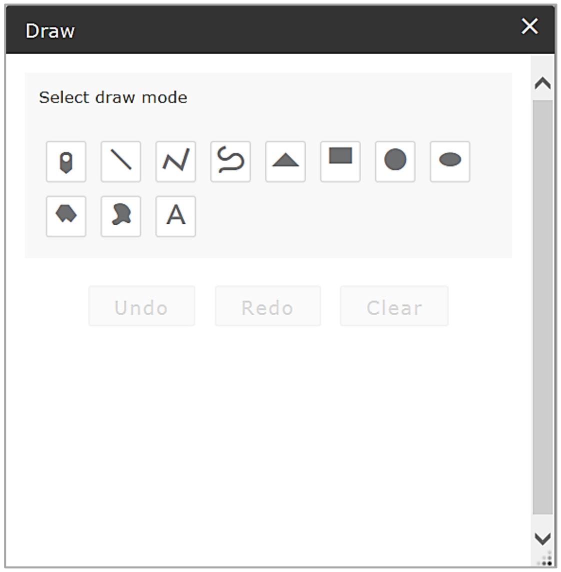
The brown one is the Incident Analysis Tool. Clicking it will open a ribbon across the bottom of the screen. Using it will be described in more detail in Example #2 below.

The gray one is the Select Tool. Clicking it will open the Select window to allow the user to select certain points of interest in either the Buyout locations or the Saferoom locations. More description of how to do this can be found in Example #3 below.

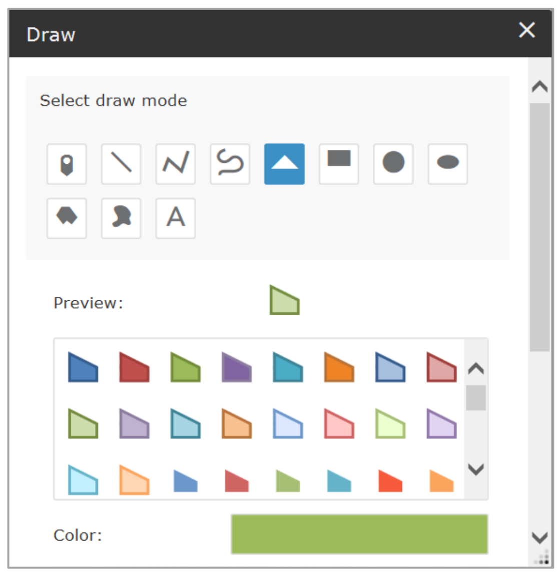


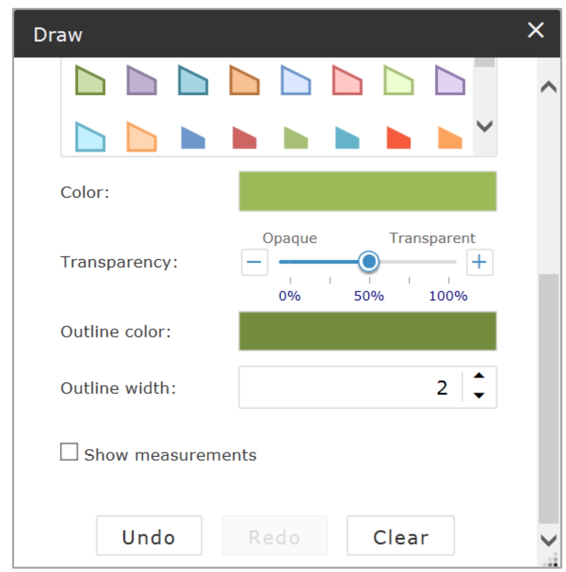


Clicking on the **Draw tool** in the upper right of the screen will activate this window.

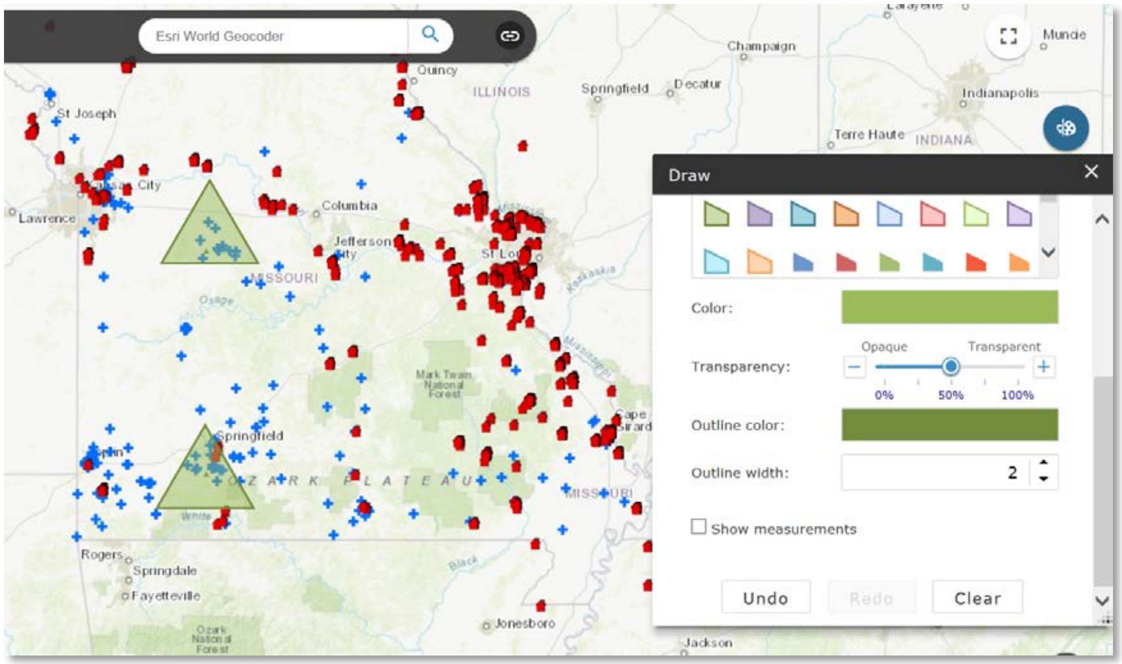


Clicking on any of the **draw mode icons** will activate a preview window with color selections. Use the scroll bar on the right to see more options to customize the color, transparency, outline color and width. Using "Undo" erases the shapes in order of creation, "Redo" will add them back in order of creation and "Clear" will erase all of them.

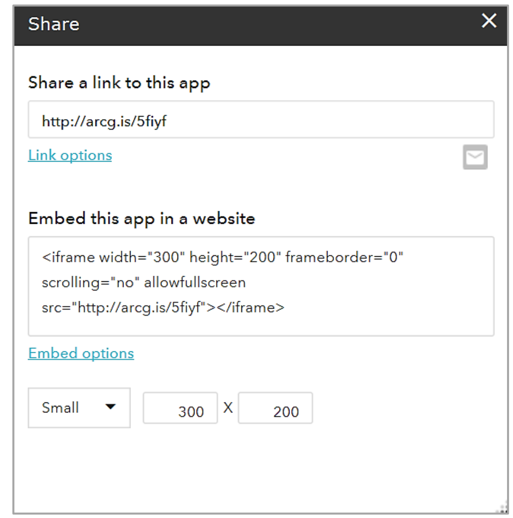




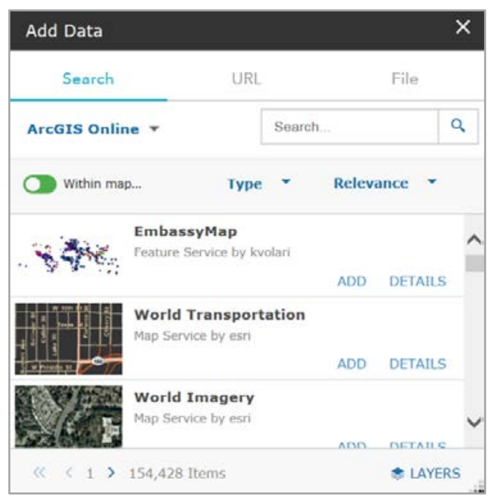
This function can be used show areas of interest on the map which can be printed or saved as a pdf for future reference.

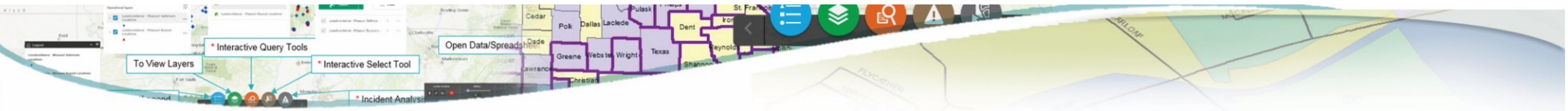


The "**Share**" button in the upper right of the screen opens the Share window giving the user the ability to share the map with others or embed the app in a website. Clicking the envelope button on the right of the window will open an email using your default email account with the link in it.



To **Add Data** for analysis, click this icon in the upper right of the screen and the Add Data window will open. Data from web services or user input can be added here.



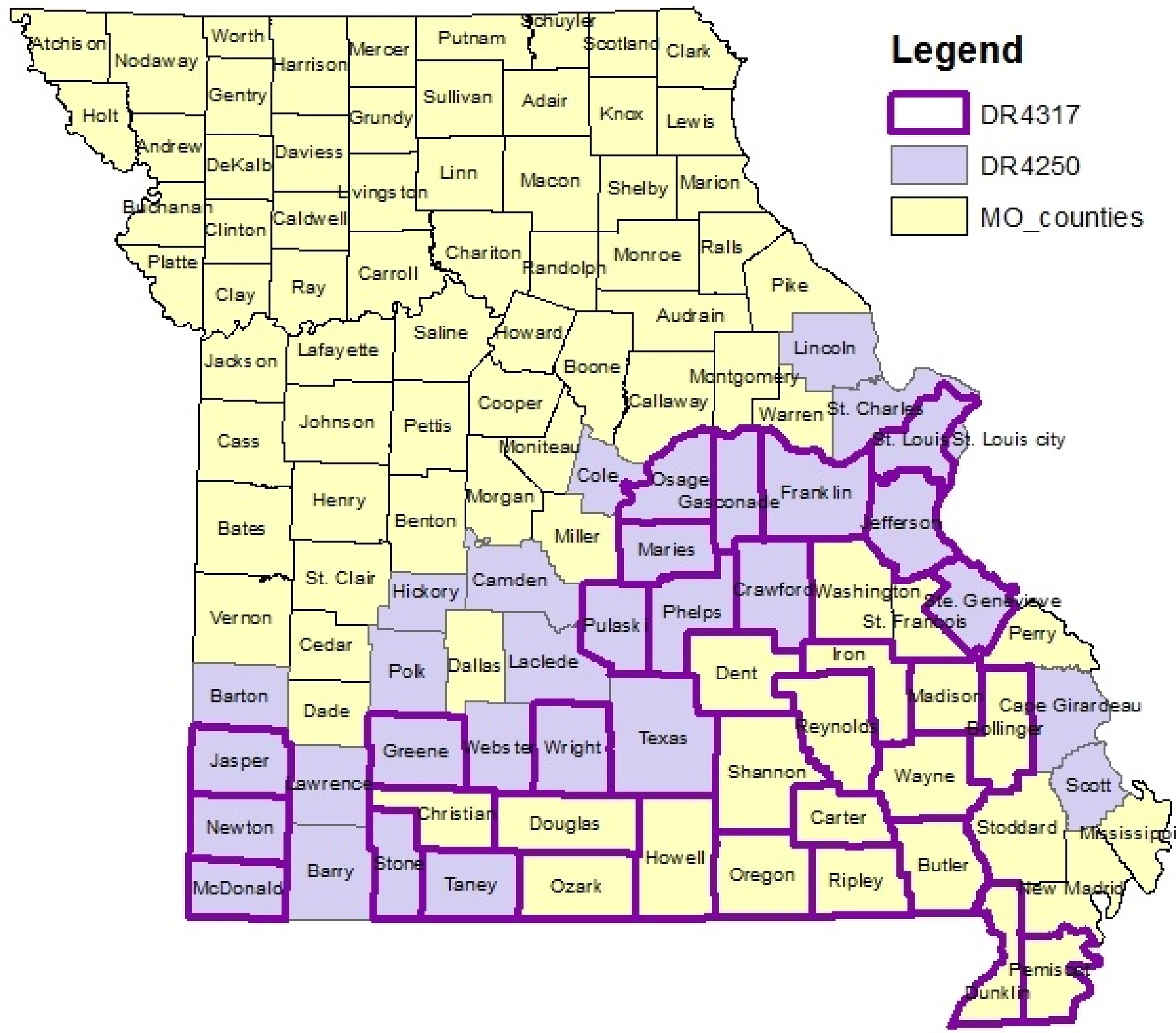


Example #1

The following is a Specific example using the LAAT for additional DR-4250 and DR-4317 for the Buyout Locations Disaster wide.

Preparation

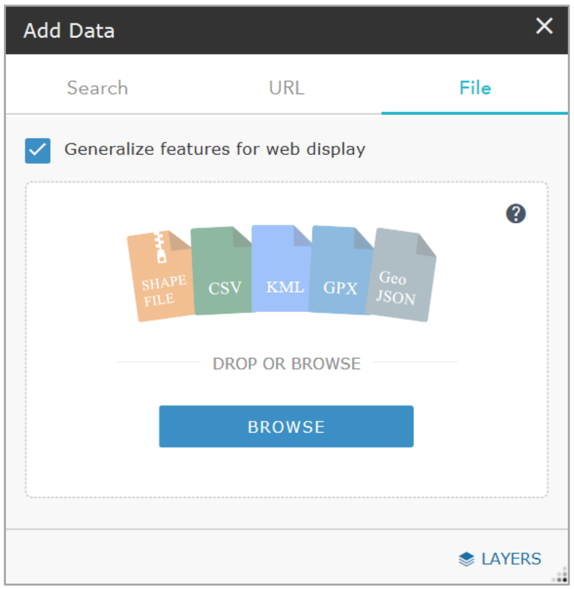
The input used is a list of the affected counties for each disaster declaration. Two shapefiles of the two disaster declared areas were used in this first example. The graphic to the right shows the affected areas.

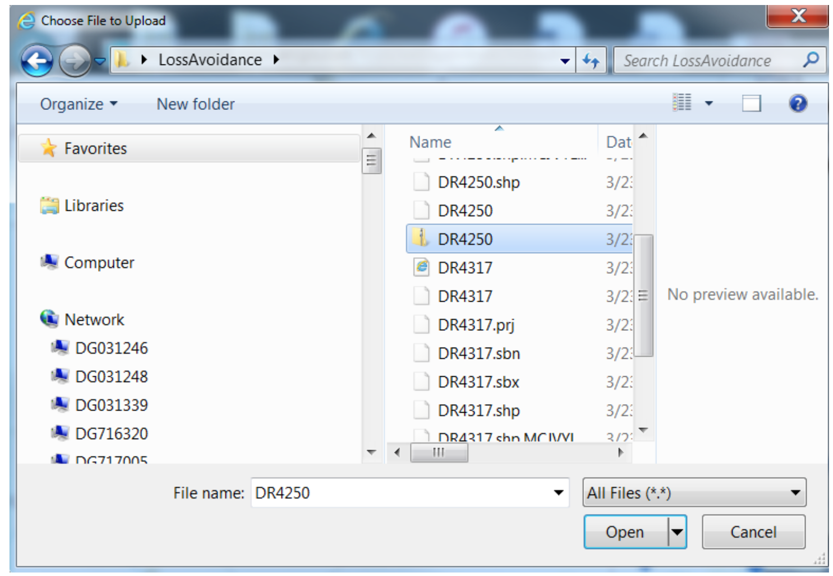


Log into the LAAT website at http://bit.ly/SEMA_LossAvoidance

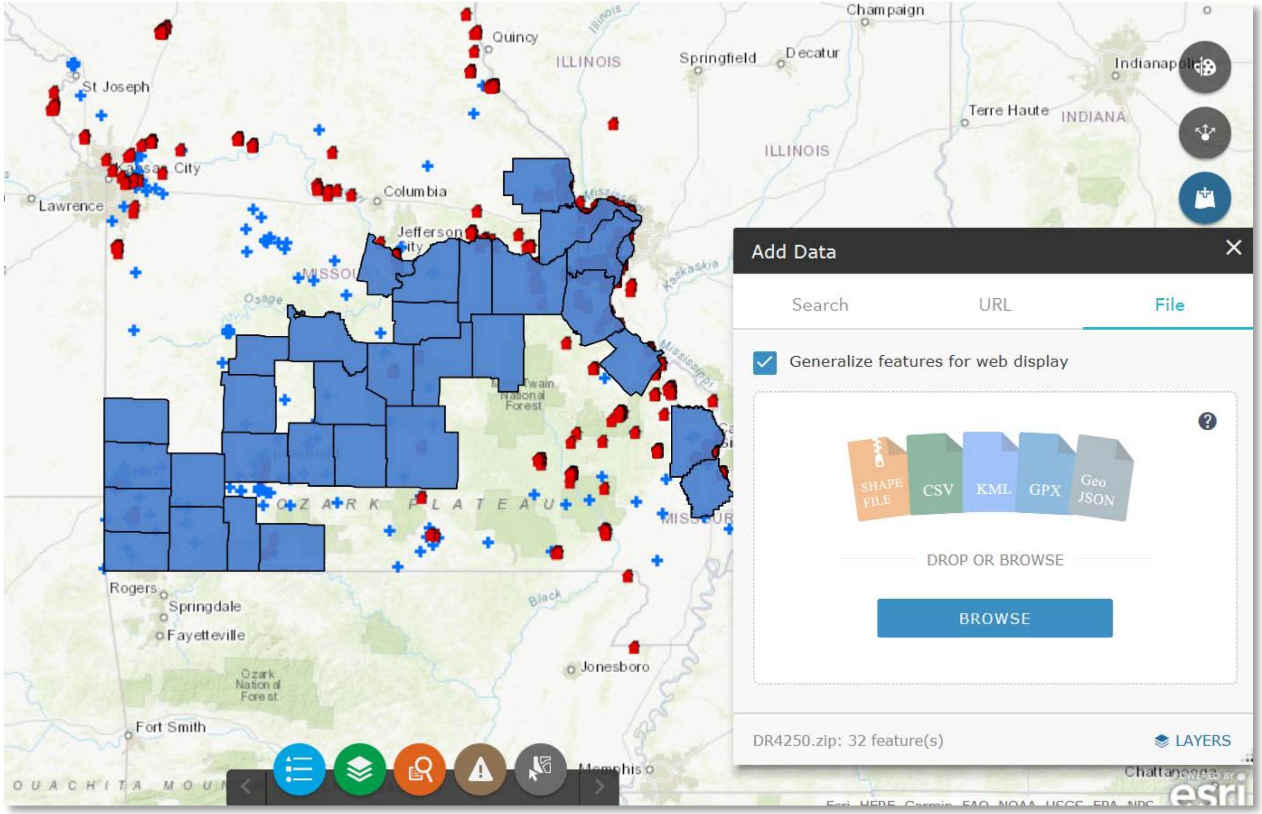
In this example, we'll add the affected areas for DR4250 first. Click on the File tab. The user can either drag and drop a file or can navigate to it using the Browse button. Shapefiles, CSV, KML, GX or GeoJSON file formats may be added. If you click Browse, then another window will open for navigation. Note that shapefiles will need to be zipped for this function. Ensure that any locks on the shapefiles are not included in the zipping. Click "Open" and the website will unzip and display the files as shown in the graphic on the next page.

Each of the windows for Draw, Share and Add Data can be closed by clicking the X in the upper right corners.

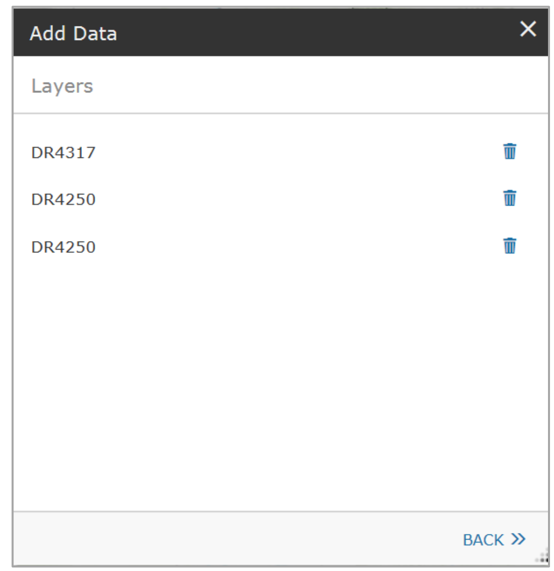




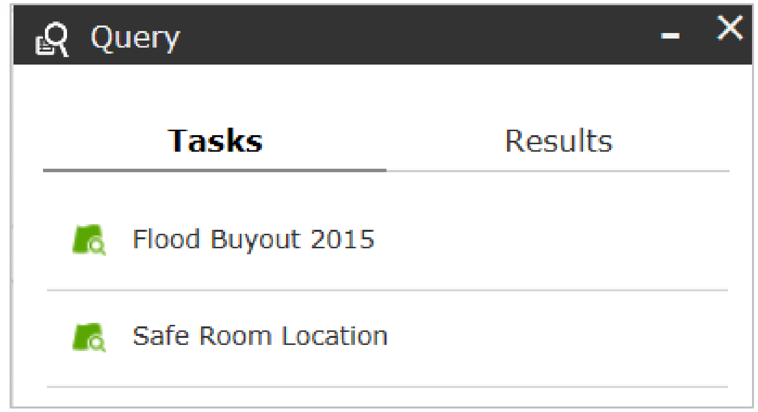
This graphic shows the addition of the DR4250 disaster declaration areas.



Layers can be removed by clicking the Layers button at the bottom right of the Add Data window. The box will activate the Layers List. Remove layers by clicking on the trashcan icon to the right of the layer. Clicking back at the bottom right will return the user to the previous screen.

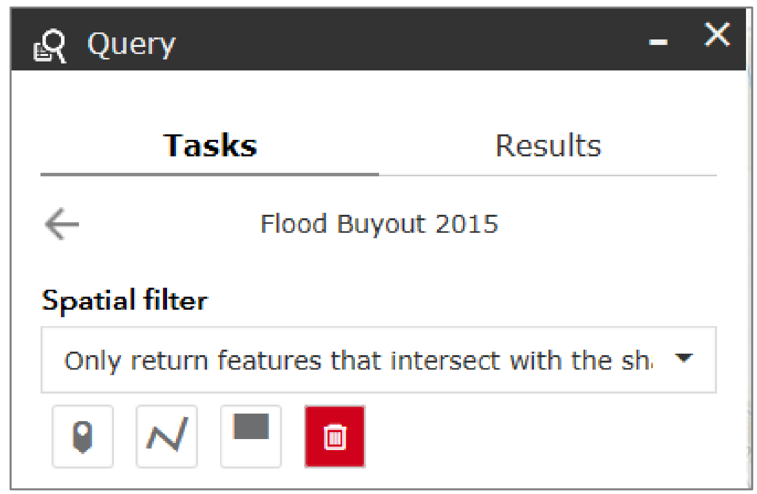


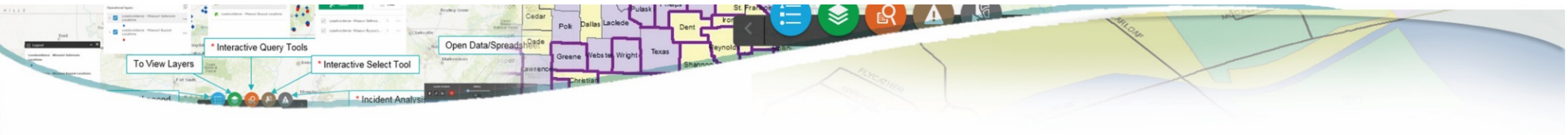
Open the Query Window and it will reveal the layers present in the tool as shown to the right. Click on the Layer wanted for the analysis. In this example, choose Flood Buyout 2015.



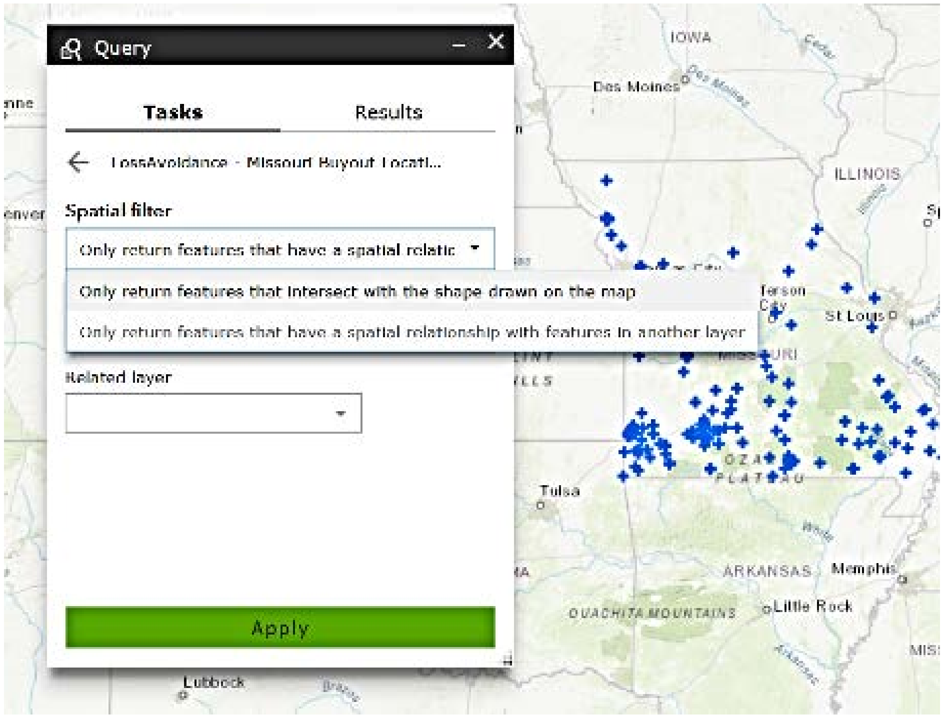
The Spatial filter dropdown menu will give the user the option to query results that have a spatial relationship (intersect or inside) with a shape drawn on the map or with features in another layer.

For this example, choose the second (Only return features that have a spatial relationship with features in another layer).

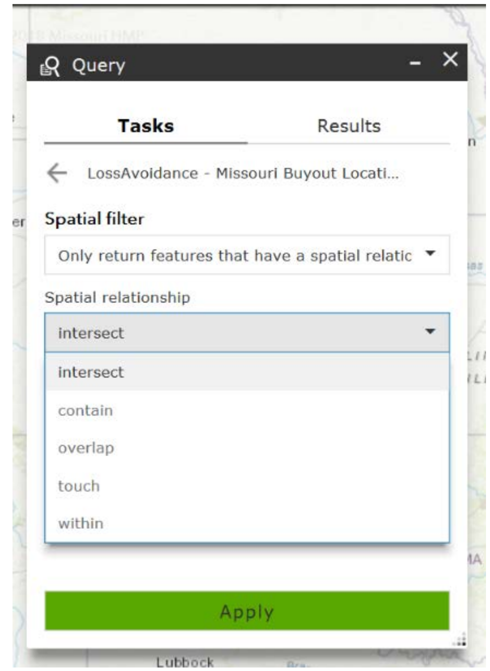


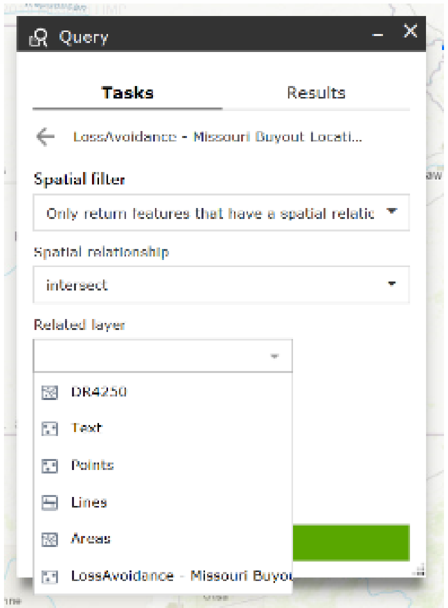


Under Spatial Relationship, the drop-down arrow allows the user to return results that intersect, contain, overlap, touch or are within the area of interest.



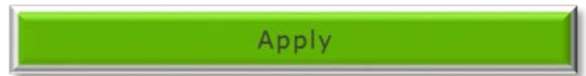
For this example, choose “intersect”. This will be the most common choice.



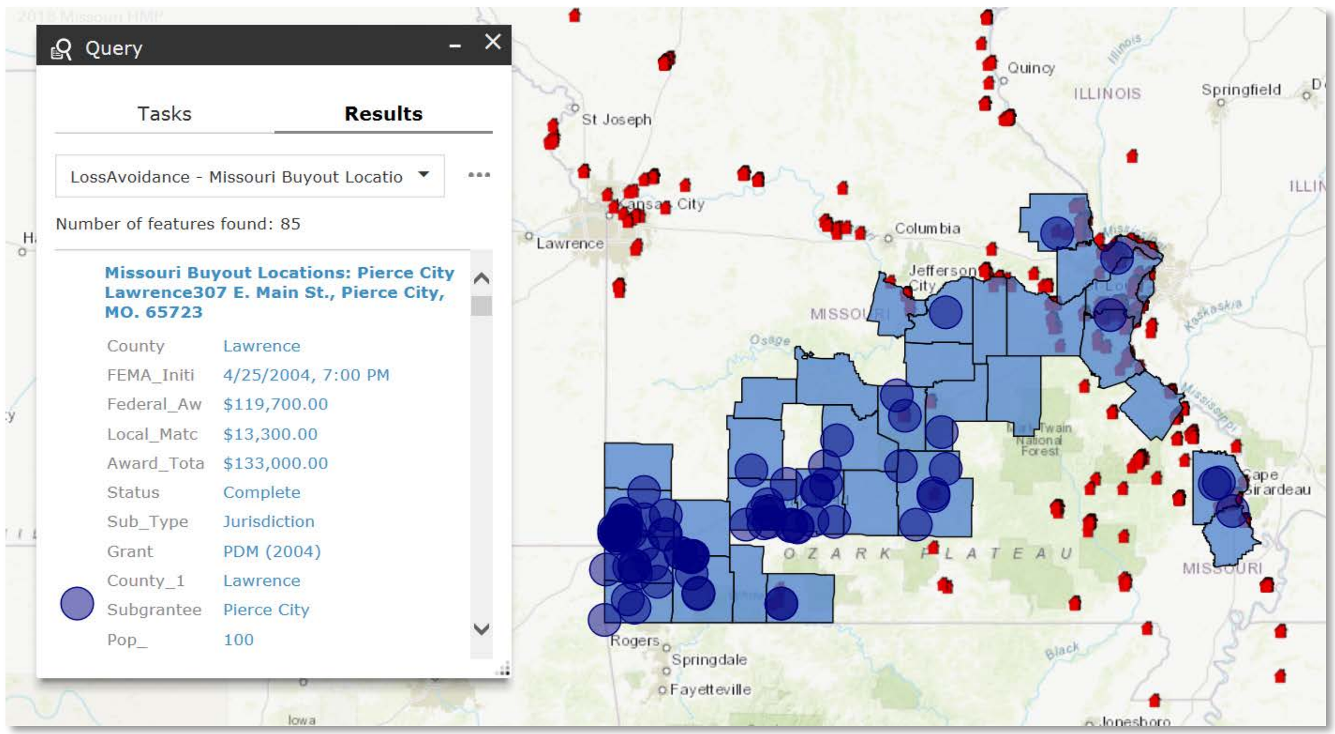


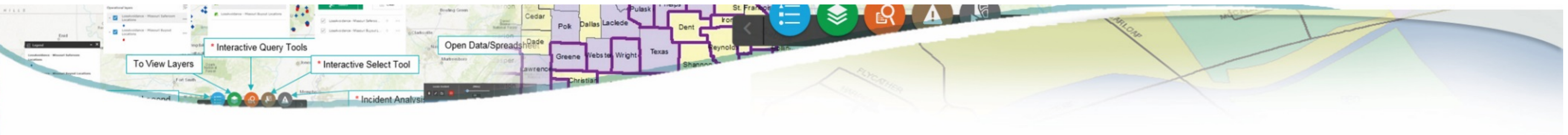
The Related layer drop-down list will allow the user to select which layer to compare against. For this example, DR4250 was chosen.

Click the green Apply button at the bottom.

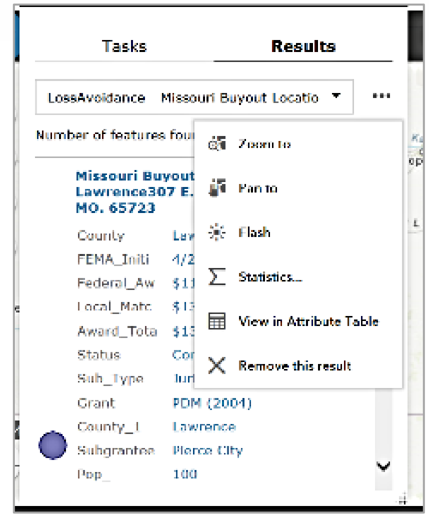


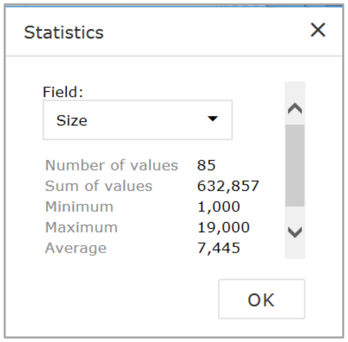
The results will appear on the map as shown below. The results in this example returned 85 buyout locations within the DR4250 declaration zone.





Clicking on the three gray circles to the right of the box that says “Loss Avoidance – Missouri Buyout Location” in the graphic above will provide the user the options to Zoom to extent, Pan to, Flash (the results will flash on the screen), Statistics (run statistics on the results), View in Attribute Table or remove the result from the map.

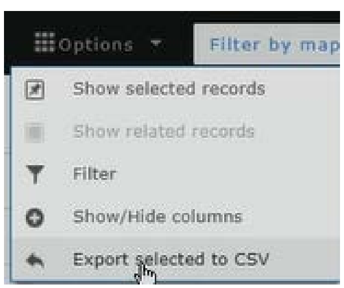


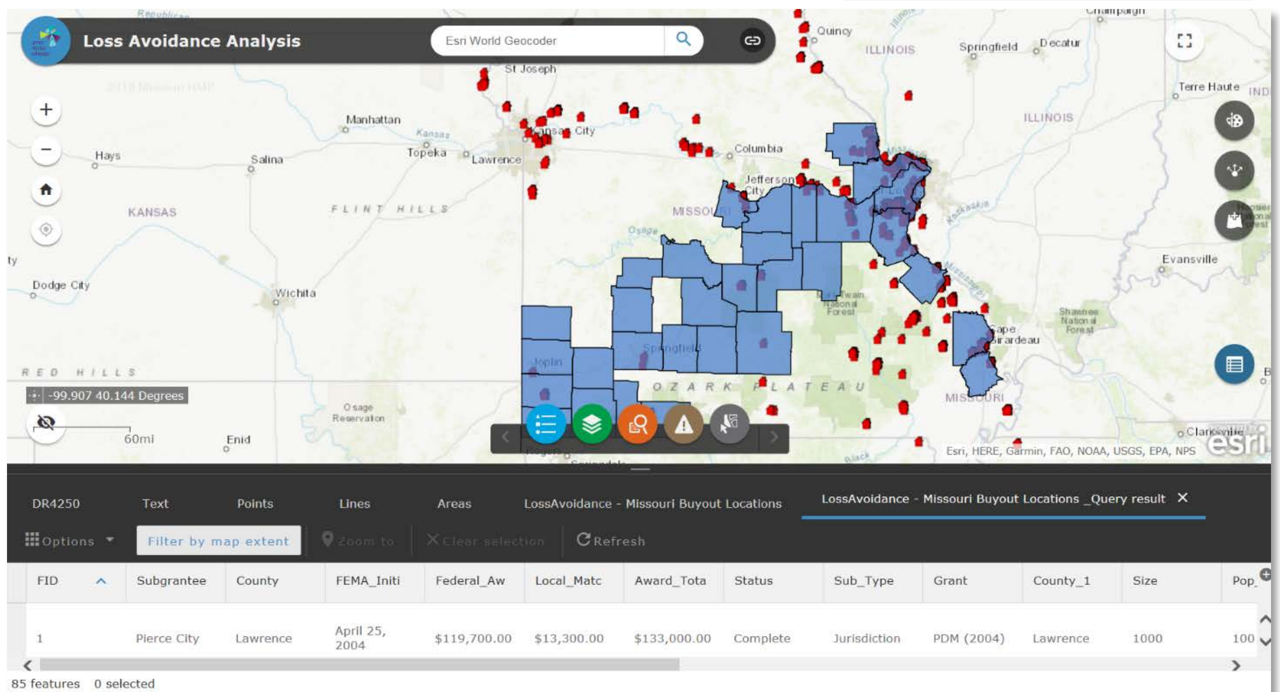


In this example, statistics were calculated for the results returned. Click “OK” to close the box.

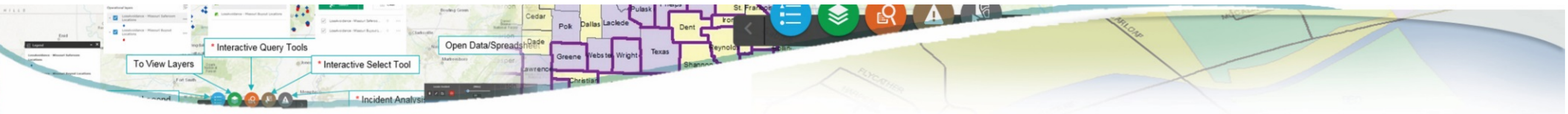
For this example, choose the “View in Attribute Table” option. The attribute table will open at the bottom of the screen.

Clicking on the drop-down arrow on the Options tab on the right side of the black attribute header, will reveal options in the graphic to the right. Choose the “Export selected to CSV” option and navigate to a location to save the file. CSV formats files can be opened in either Excel or ArcMap. Instructions for this can be found on page 24.



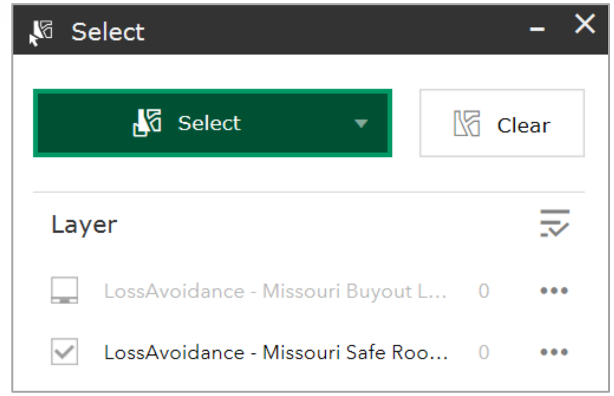


*Note that if the query results in more than 1,000 locations, only 1,000 attributes will be exported. It is recommended to break the query up into smaller parts to remedy this.



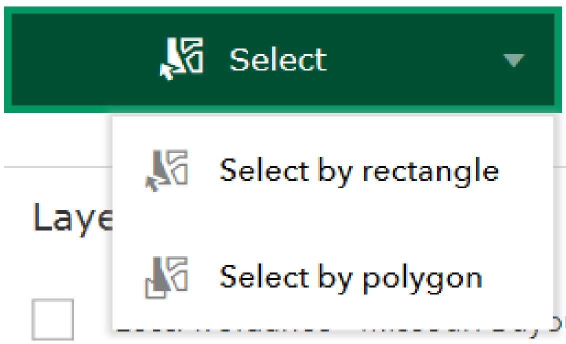
Example #2

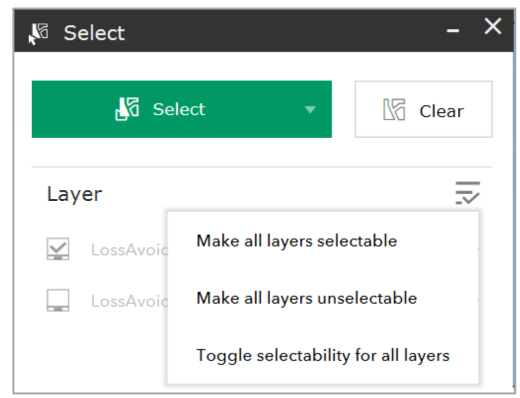
In this example, we will mimic the path of a severe thunderstorm with tornadoes in it.



Selection can be done by using the  Select button in the bottom banner which activates the Select window.

Clicking the green Select button will reveal the Select by rectangle option or Select by polygon option.



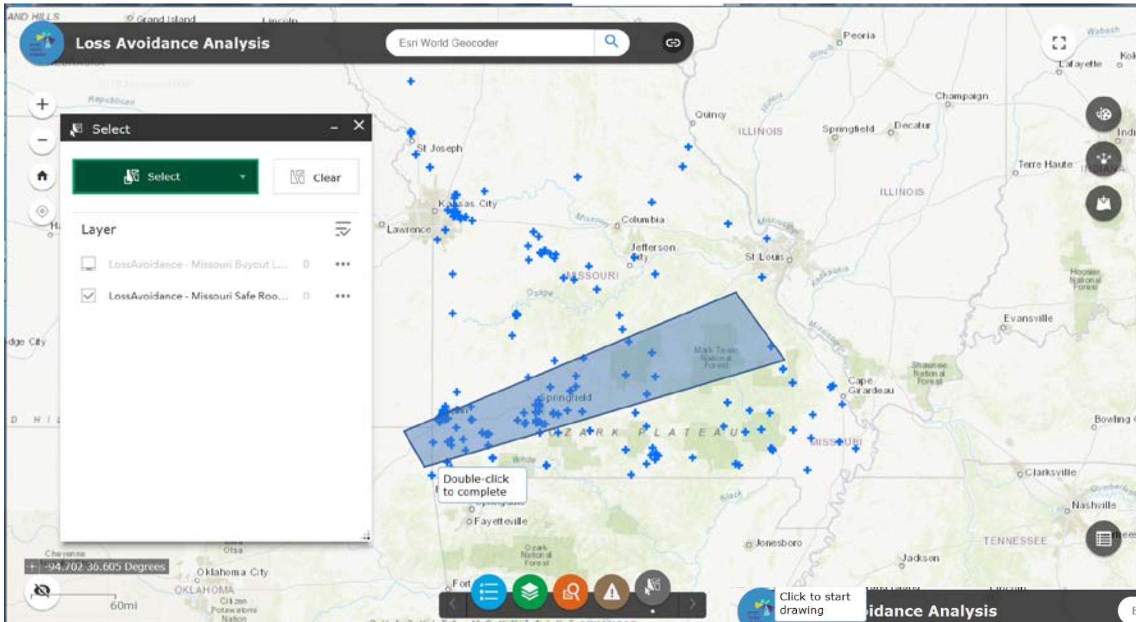


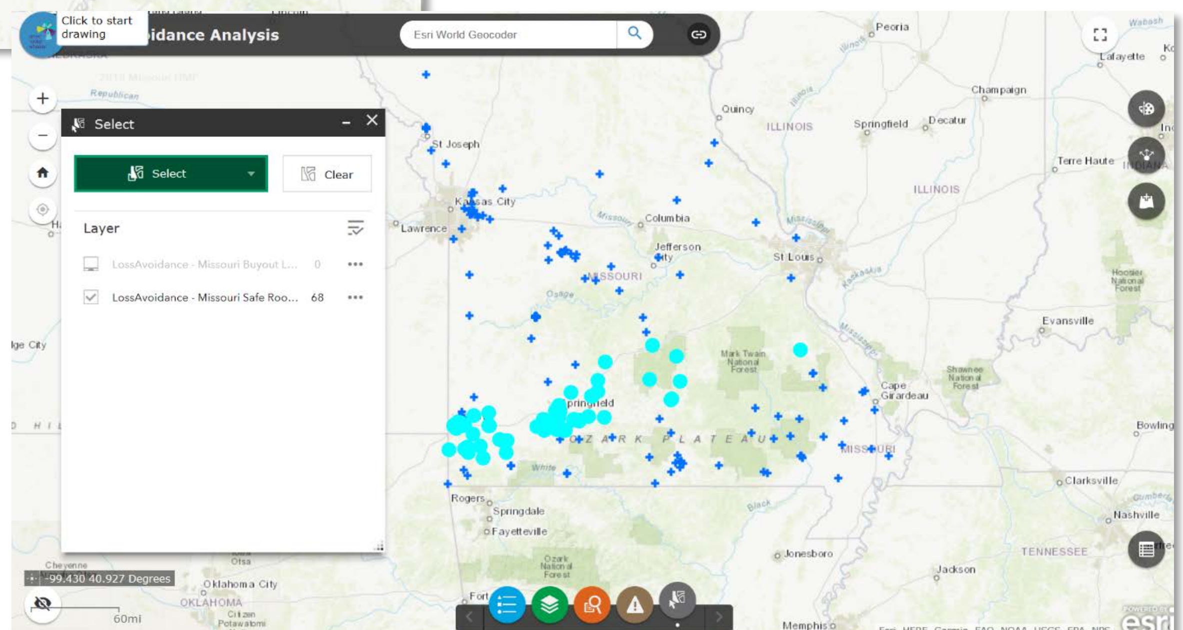
Choose either Select by rectangle or polygon. Ensure that the layer for Saferoom (or Buyout in other scenarios) is active by clicking the checkbox next to the layer name.

The layers can be made selectable/in-selectable by clicking the checkmark with the three bars icon in the center right and choosing one of the options that appear.

Clicking the Clear button to the right of the green button will clear out the selections.

In this example, the user will mimic the path of the storm by drawing an area of interest using the polygon. Click on the map once to start the polygon, click again to add vertices and double click to complete the polygon.

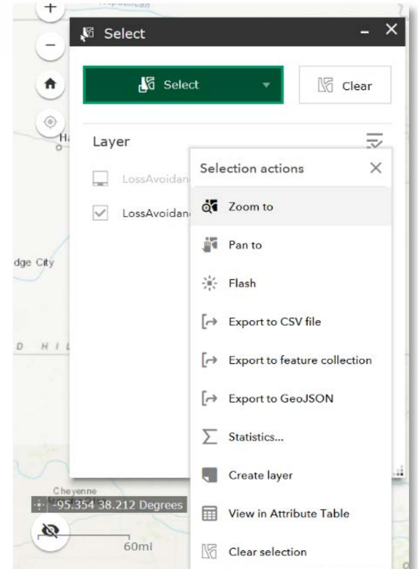


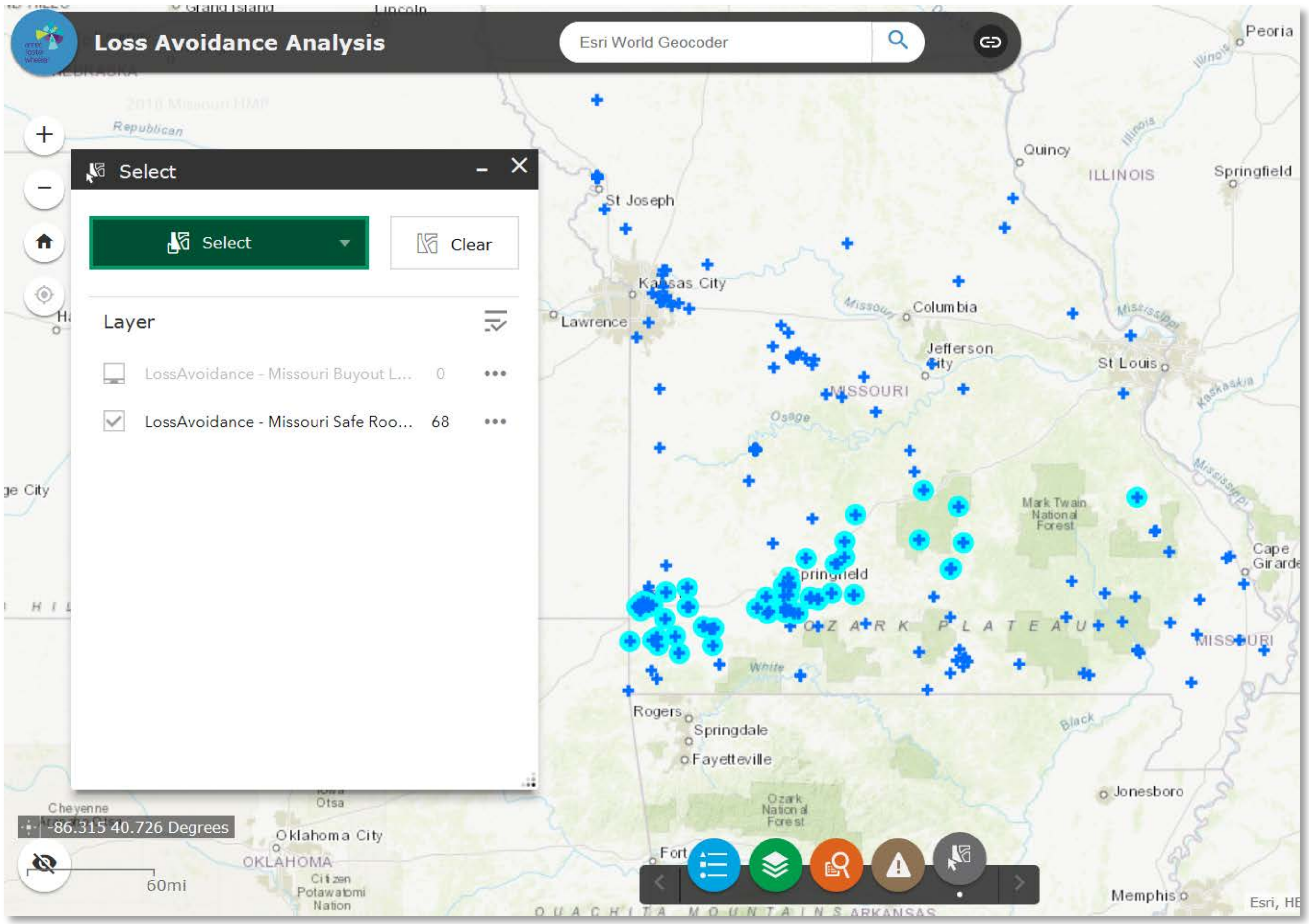


The Saferoom locations inside the polygon drawn will be selected and highlighted on the map.

The selection can be cleared by tapping the clear button to the right of the green Select button. In this example 68 saferooms were returned in the results which is also shown next to the name of the Layer in the Select Window circled in red in the graphic above.

Clicking on the three gray circles to the right of the results number, will reveal a number of options to u for viewing or exporting. In this example, “Create a Layer” was chosen. The user will be prompted to name the layer, Tornado XYZ Damage Area, in this example. This adds the selected Saferooms to the map in a new layer.

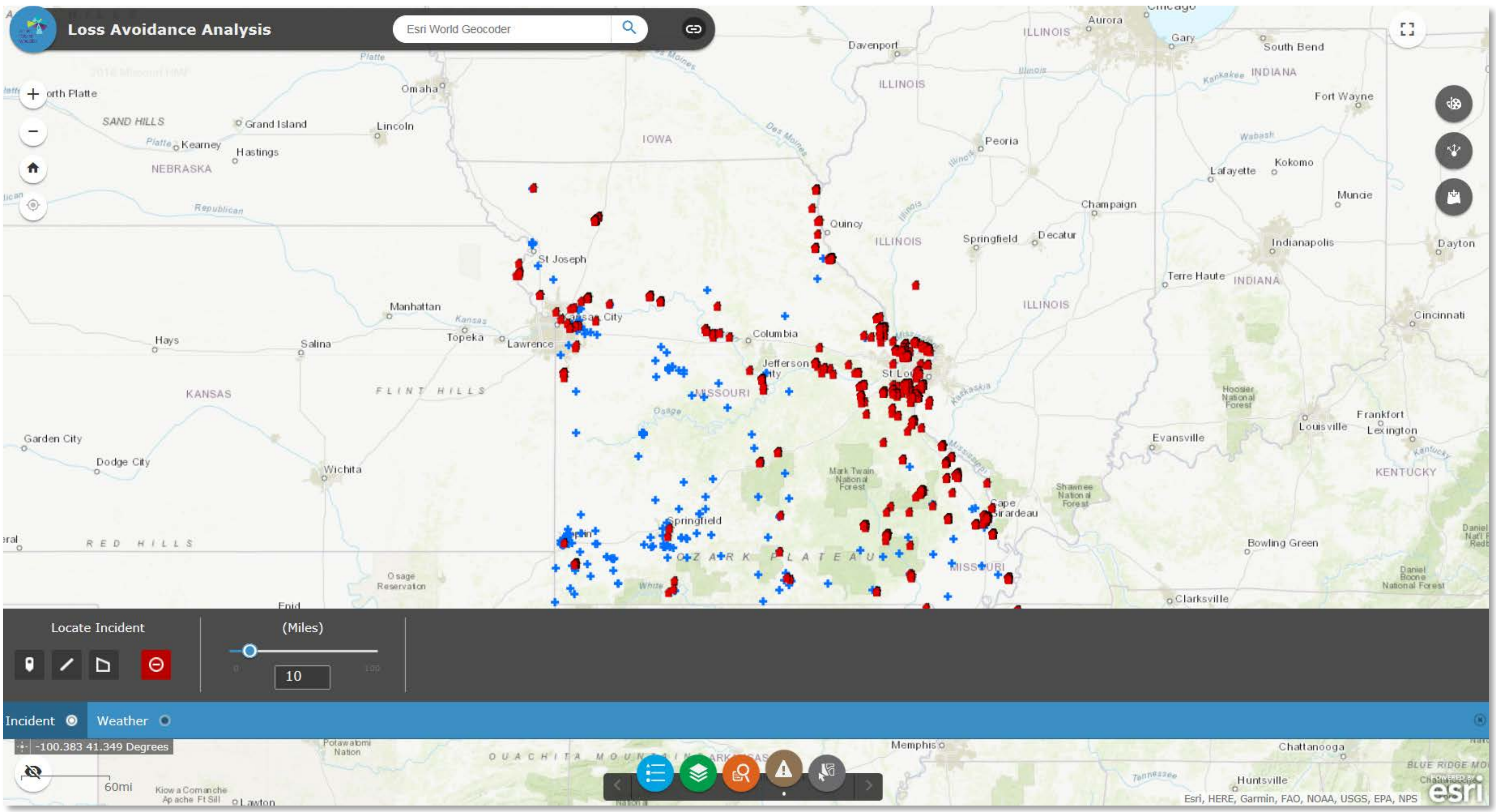




Example #3

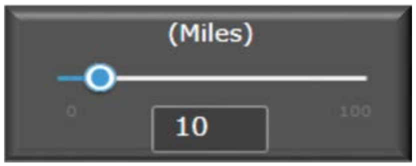
Click the brown button on the bottom banner to activate the Locate Incident ribbon. A buffer distance in miles can be set around the incident by moving the slide bar

The Locate Incident ribbon can be closed by clicking the small black X at the bottom right of the ribbon.

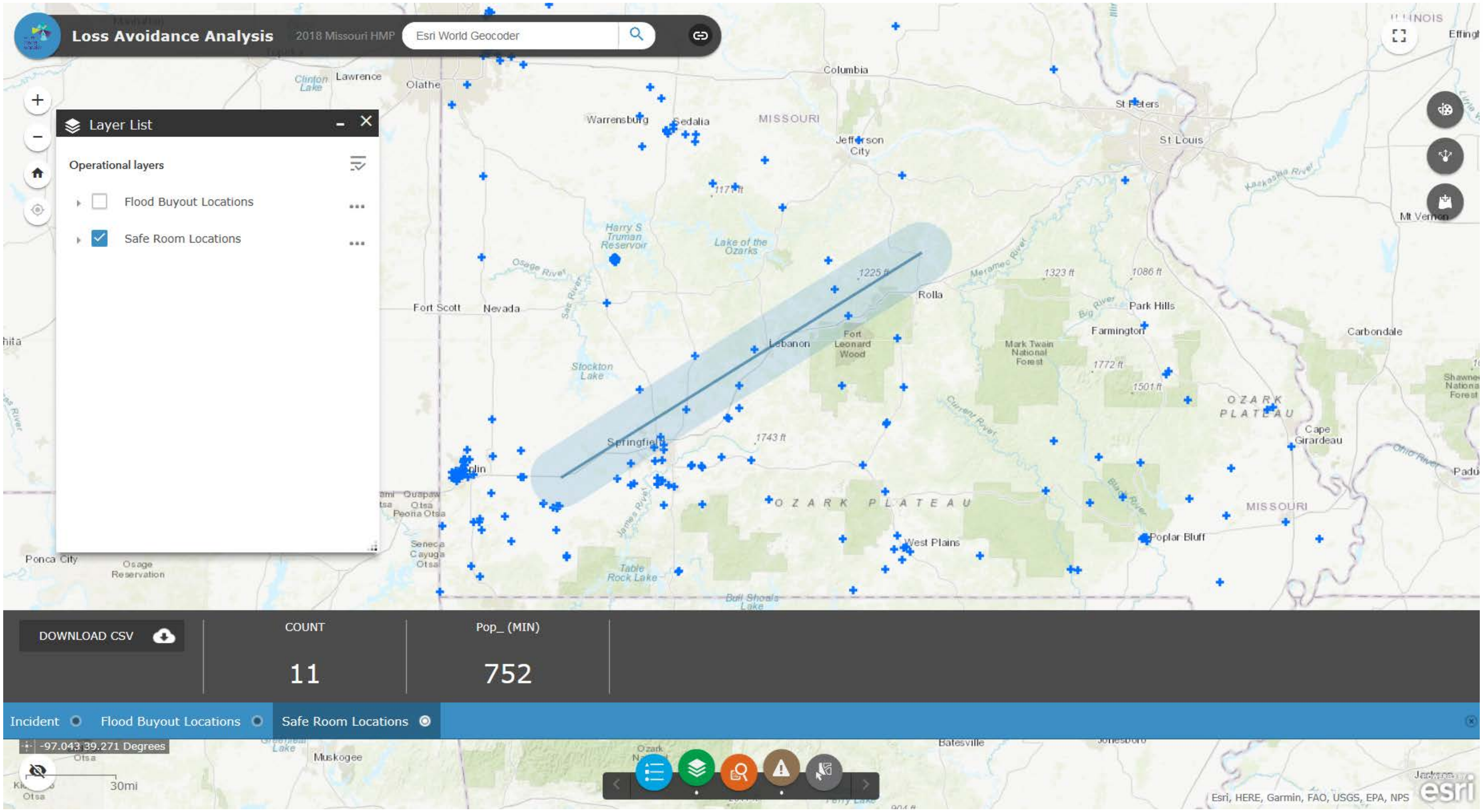


Using either the Locate Incident Buttons on the gray ribbon to simulate and incident.

The  button will all the user to draw a line simulating a storm path as shown in the graphic below.

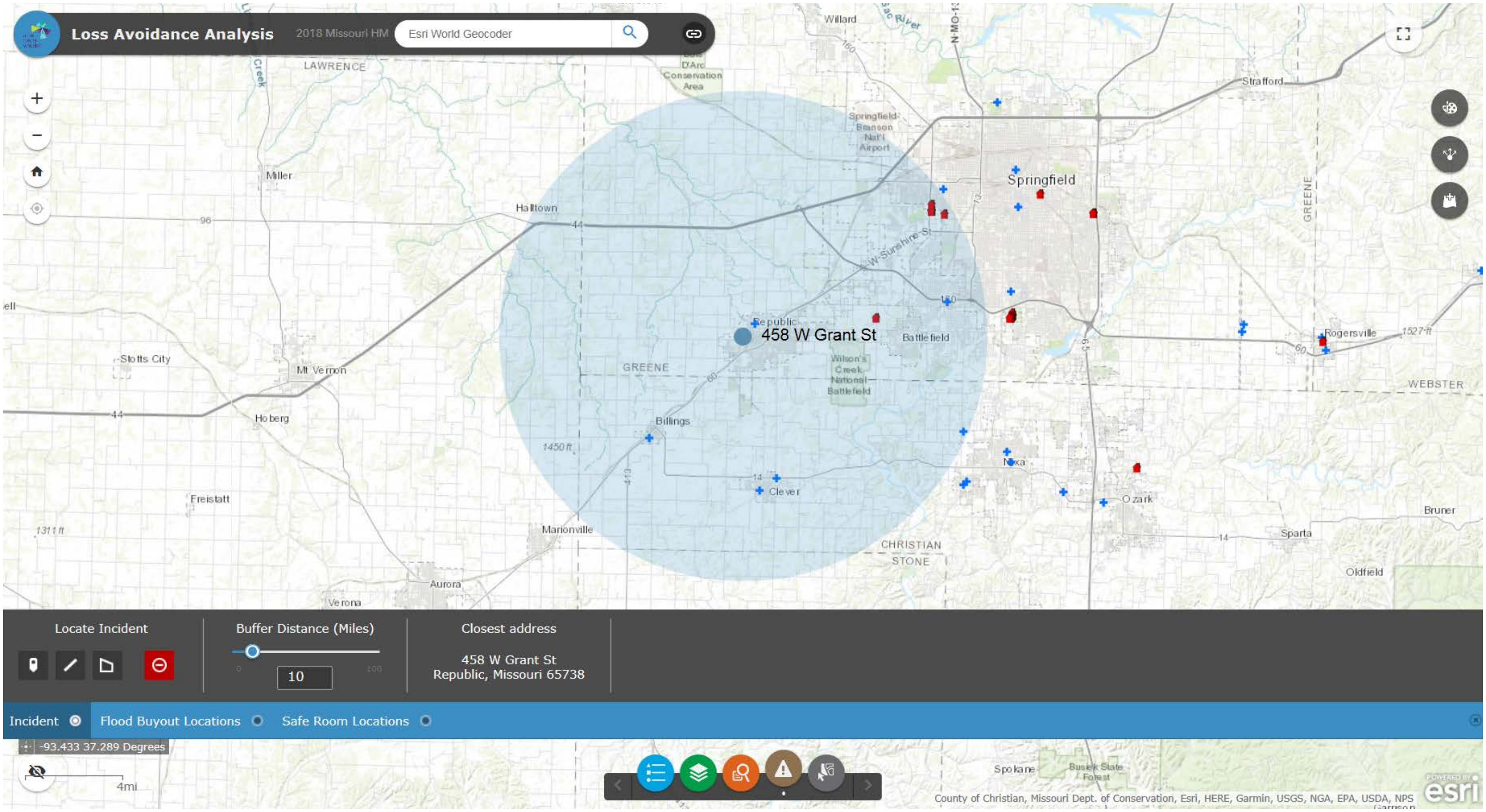
Using the 

slide bar, the area of interest on either side of line can be changed. In the example above, it is set for 10 miles. In the example below it was changed to 25 miles by sliding the blue circle to the right. Alternately, the number 25 can be insert in the number box. The display screen will automatically zoom to the extent of the incident.

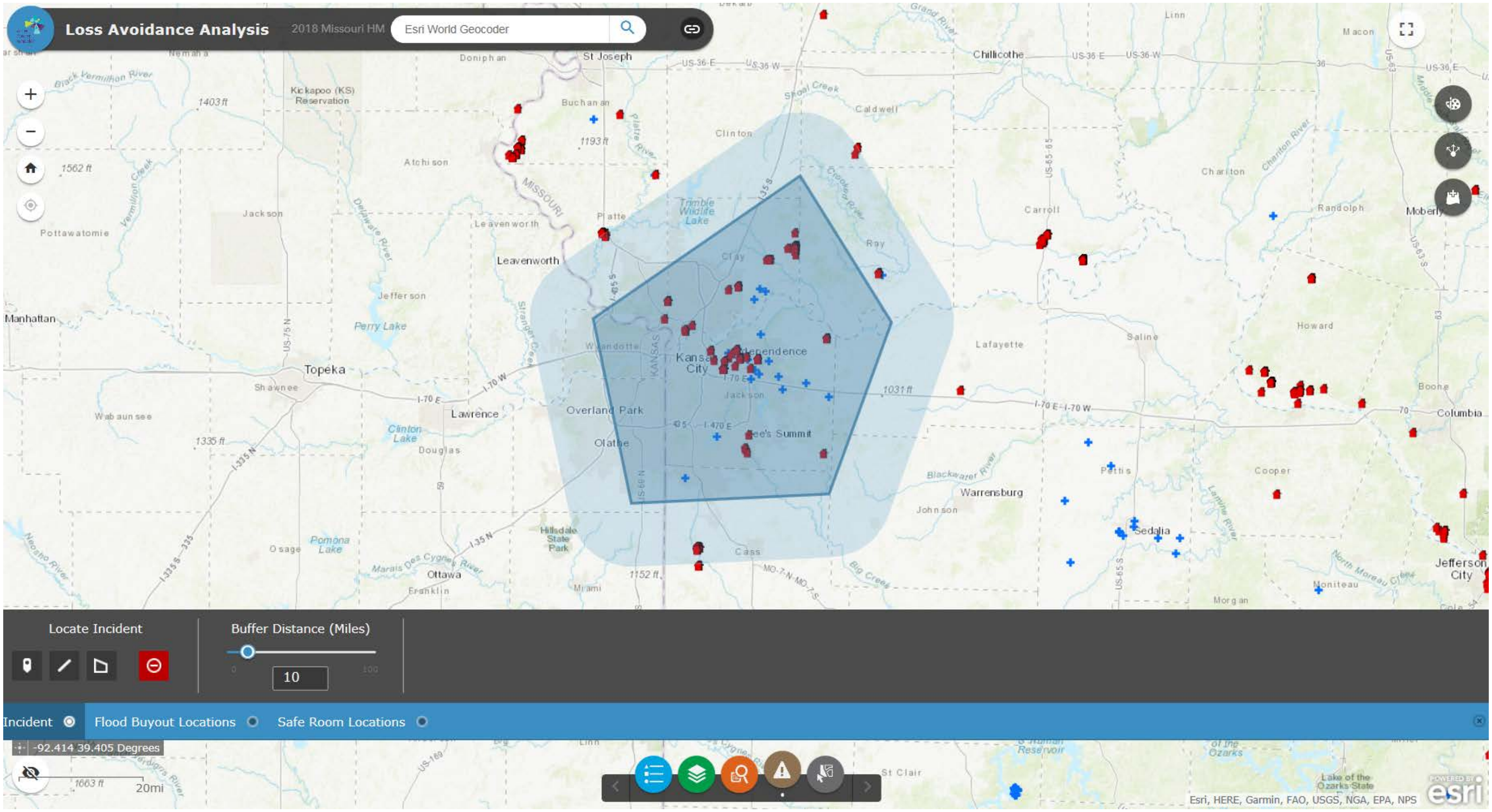


By clicking on the Layer Name in the blue ribbon along the bottom of the page, the count and population attributes for the intersection of the buffered area and the Operational Layer will be summarized in the gray ribbon. The CSV file of the selected locations can be downloaded using the Download CSV file on the gray ribbon.

The will allow the user to drop a point on the map with the buffer applied as shown below.



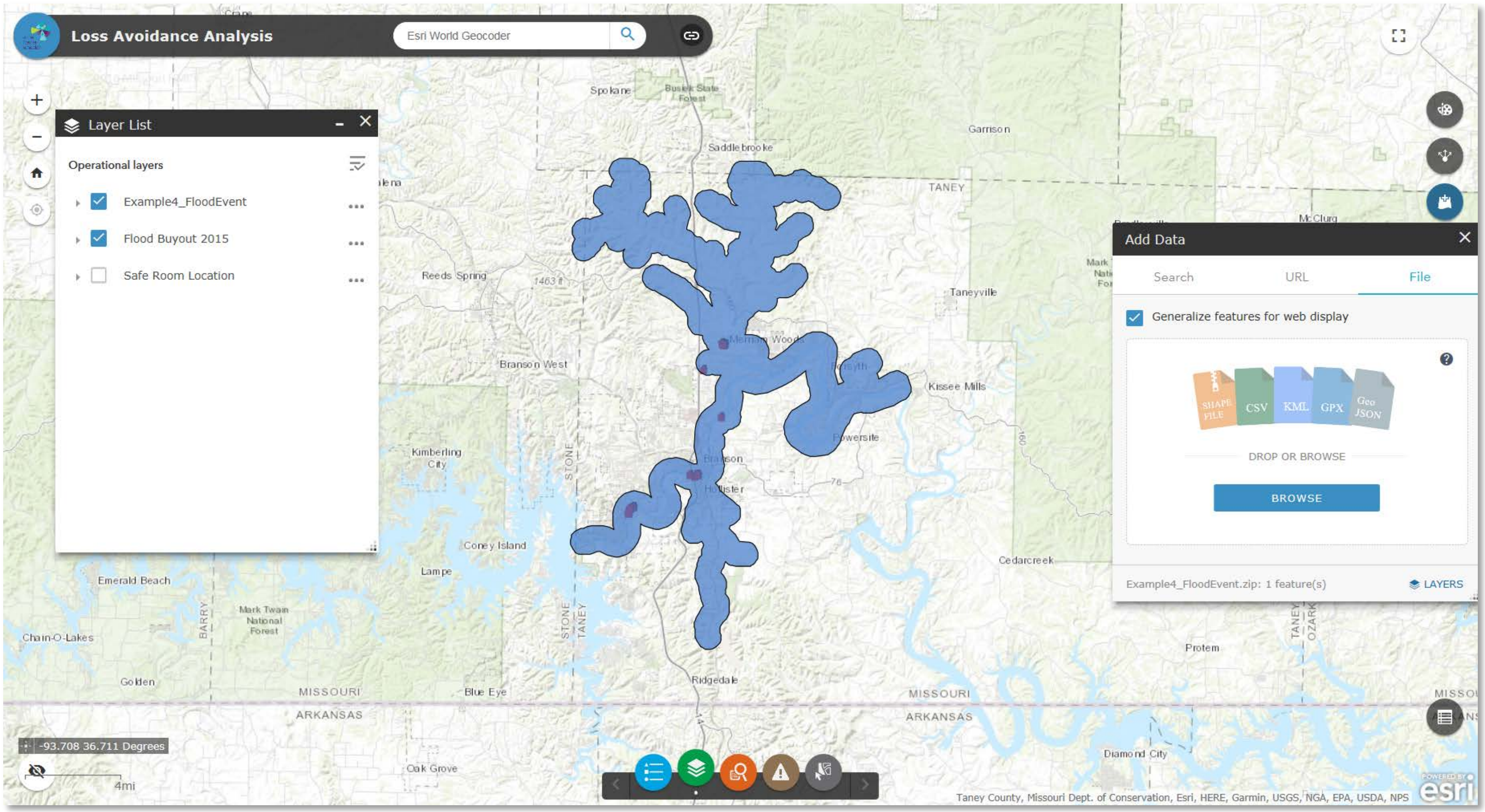
The  will allow the user to create a polygon on the map as shown below.



The  allows the user clear or remove the incident on the map.

Example #4

Another example of using the LAAT to generate Loss Avoidance estimates can be created using a polygon of flooding along a specific source as shown in the graphic below. Add the polygon of a specific flood event using the Add Data button. Then Query and Export as shown in Example 1.



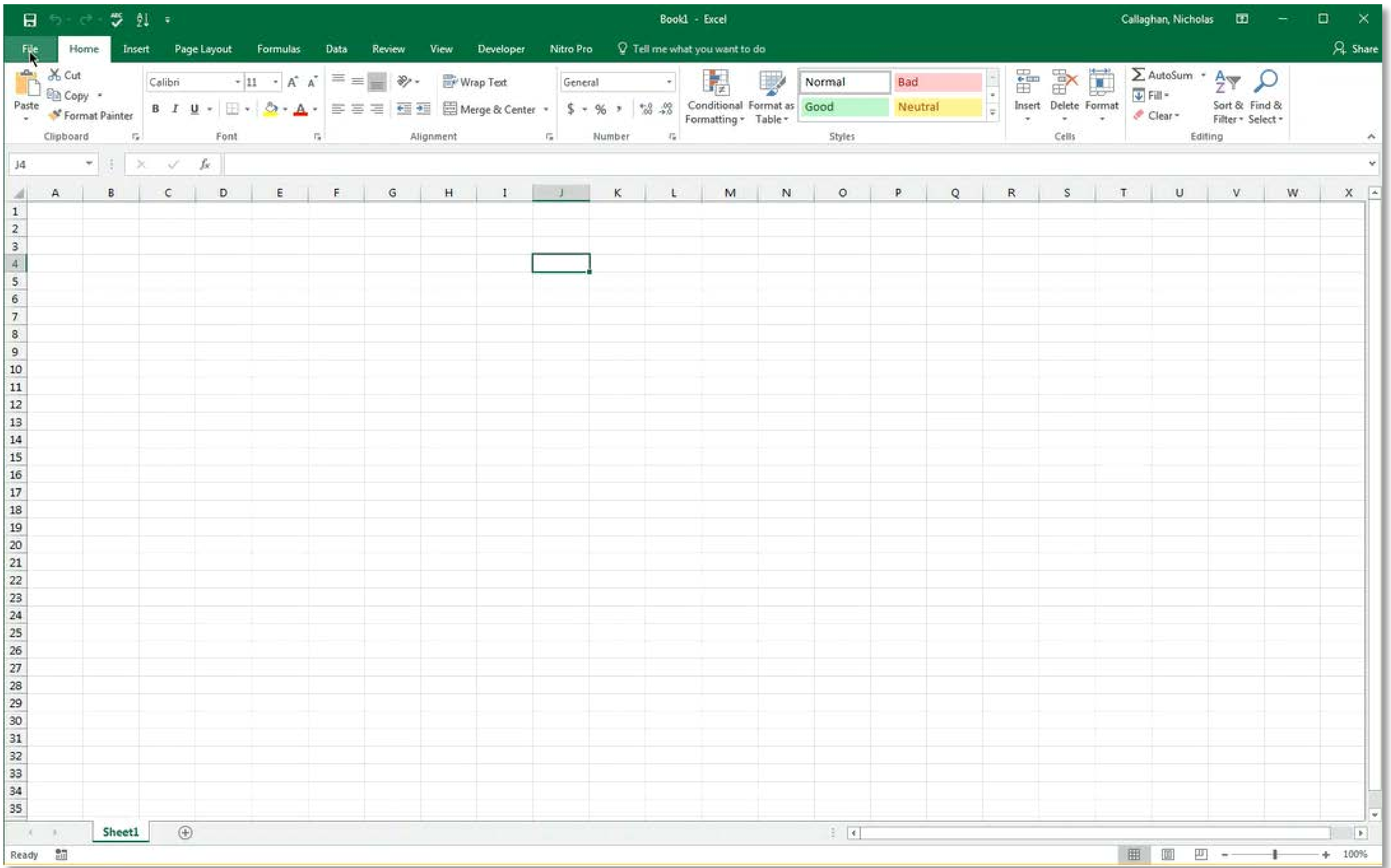
The table shown below is Table 7.11 from the Hazard Mitigation Plan and was generated from the LAAT exports utilizing the combined methods described in Examples 1 and 4 of this guide.

Community	Total # of Acquired Structures	Total # of Acquired Structures Located within the SFHA	Total Project Investment	Avoided Loss DR 4250		Avoided Loss DR 4317		Total Avoided Loss	Loss Ratio DR 4250	Loss Ratio DR 4317	Total Loss Ratio
				Structure Damage	Contents Damage	Structure Damage	Contents Damage				
Franklin	156	101	$4,103,010	$4,321,697	$2,160,849	$4,321,697	$2,160,849	$12,965,091	1.58	1.58	**3.16**
Gasconade	6	2	$556,074	$48,354	$24,177	$48,354	$24,177	$145,062	0.13	0.13	**0.26**
Greene	18	9	$1,128,880	$431,477	$215,739	$431,477	$215,739	$1,294,431	0.57	0.57	**1.15**
Jasper	3	2	$126,341	$84,228	$42,114	$84,228	$42,114	$252,684	1	1	**2**
Jefferson	517	147	$9,338,333	$3,080,801	$1,540,401	$3,080,801	$1,540,401	$9,242,403	0.49	0.49	**0.99**
Montgomery	77	4	$328,281	$96,708	$48,354	$96,708	$48,354	$290,124	0.44	0.44	**0.88**
Newton	68	53	$1,791,146	$1,375,476	$687,738	$1,375,476	$687,738	$4,126,428	1.15	1.15	**2.3**
Pulaski	19	8	$505,225	$212,728	$106,364	$212,728	$106,364	$638,184	0.63	0.63	**1.26**
St. Charles	1456	570	$15,459,051	$12,614,507	$6,307,254	$10,352	$5,176	$18,937,289	1.22	0	**1.22**
St. Louis	676	402.5	$19,598,189	$16,348,990	$8,174,495	$16,322,430	$8,161,215	$49,007,130	1.25	1.25	**2.5**
Ste. Genevieve	81	33	$1,038,091	$390,012	$195,006	$390,012	$195,006	$1,170,036	0.56	0.56	**1.13**
Taney	23	21	$3,379,541	$3,376,649	$1,688,325	$3,325,269	$1,662,635	$10,052,877	1.5	1.48	**2.97**
Grand Total	**3100**	**1353**	**$74,073,874**	**$42,381,627**	**$21,190,814**	**$29,699,532**	**$14,849,766**	**$108,121,739**	**0.86**	**0.6**	**1.46**

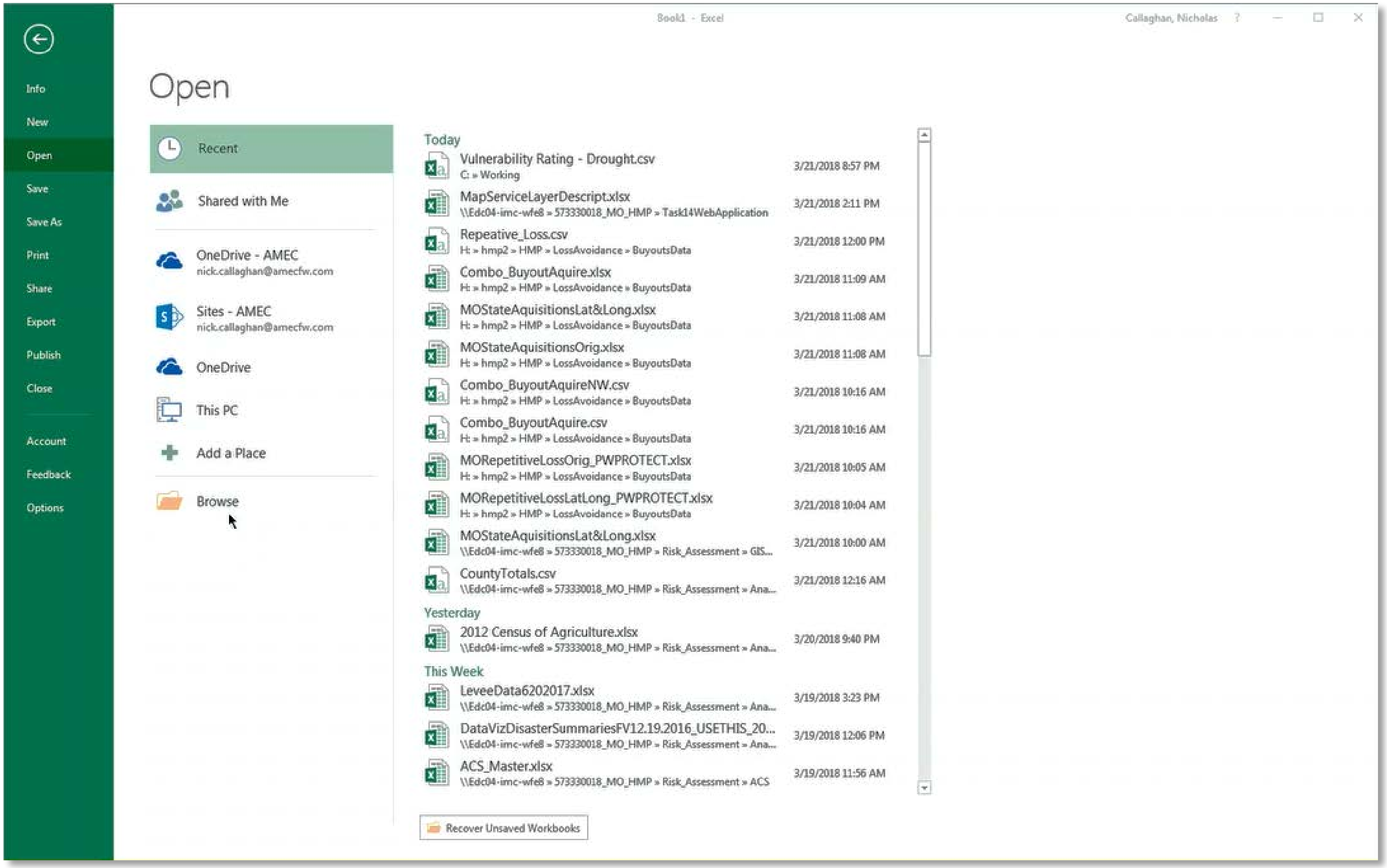
Using CSV files

To open in Excel:

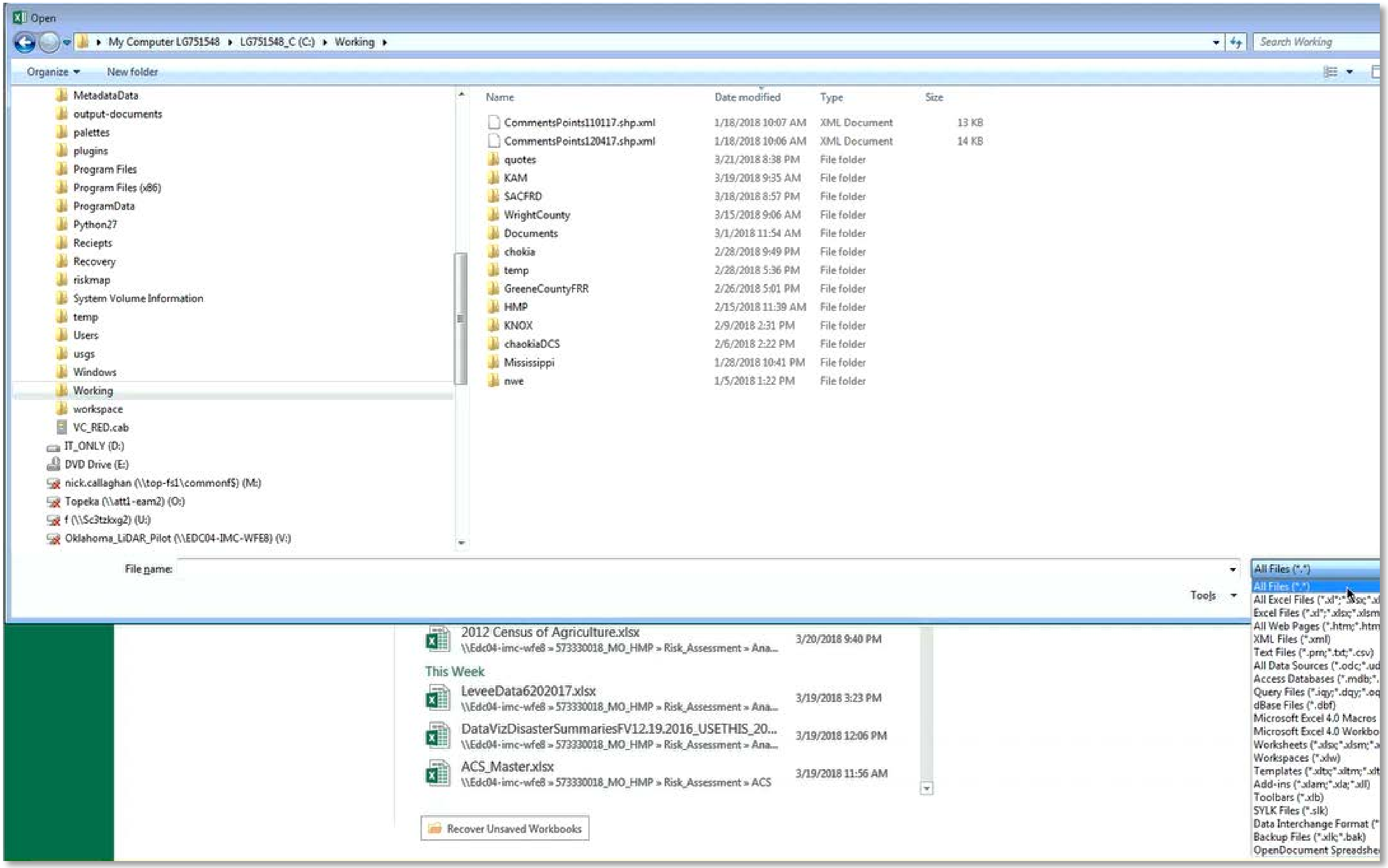
1) Open a blank Excel file.



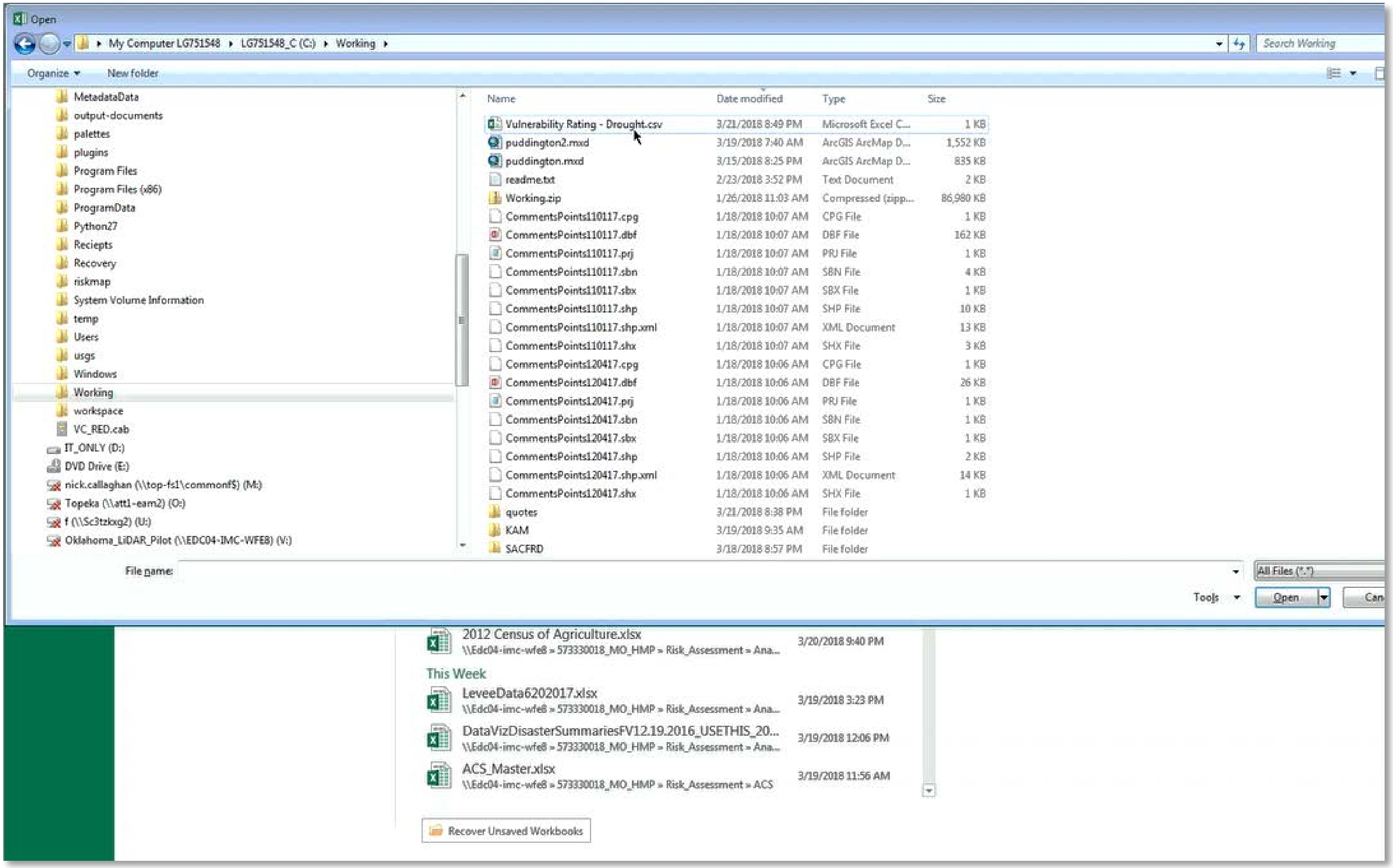
2) Click File and Browse to the CSV file



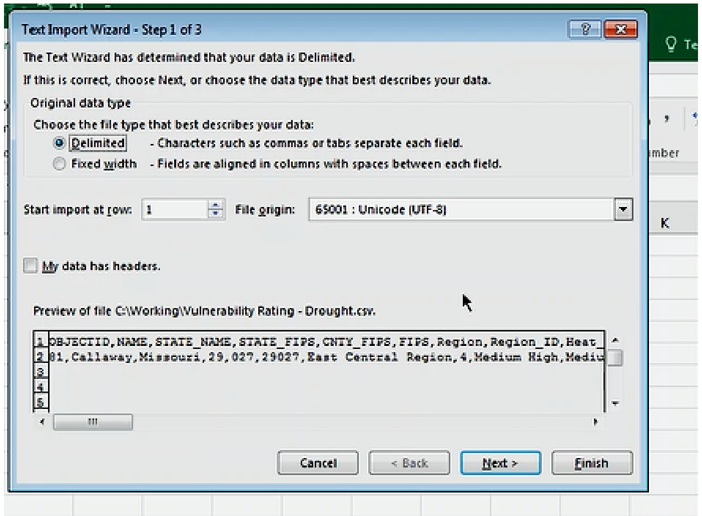
3) Navigate to the saved CSV location. Using the dropdown arrow for file types in the bottom right side of the window, choose “All Files (*.*).



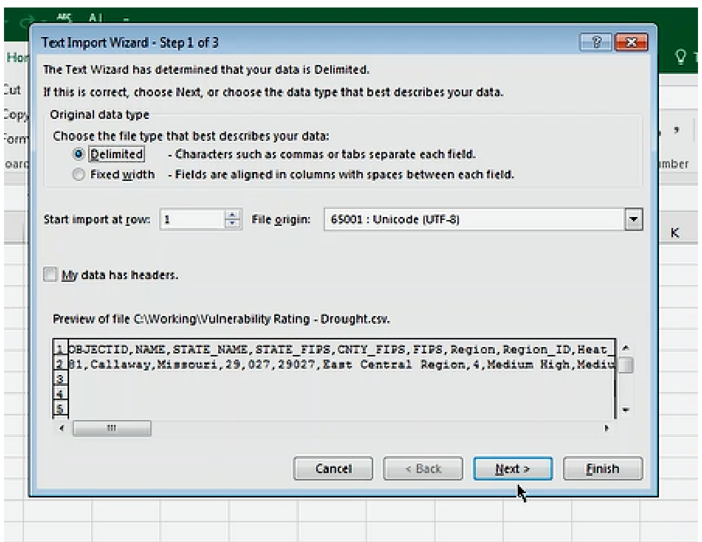
4) **Click on the CSV file in the File Name window.**

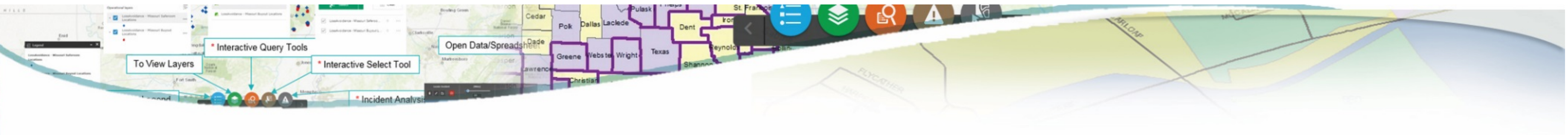


5) A Text Import Wizard window will open showing Step 1 of 3. Choose the “Delimited” radio button in the upper middle of the window.

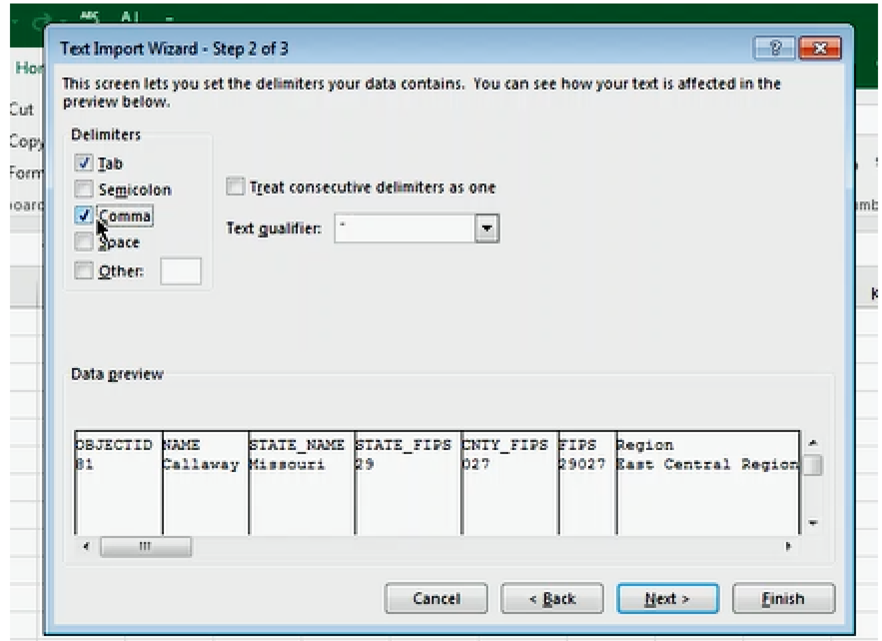


6) Then Click “Next” at the bottom right.

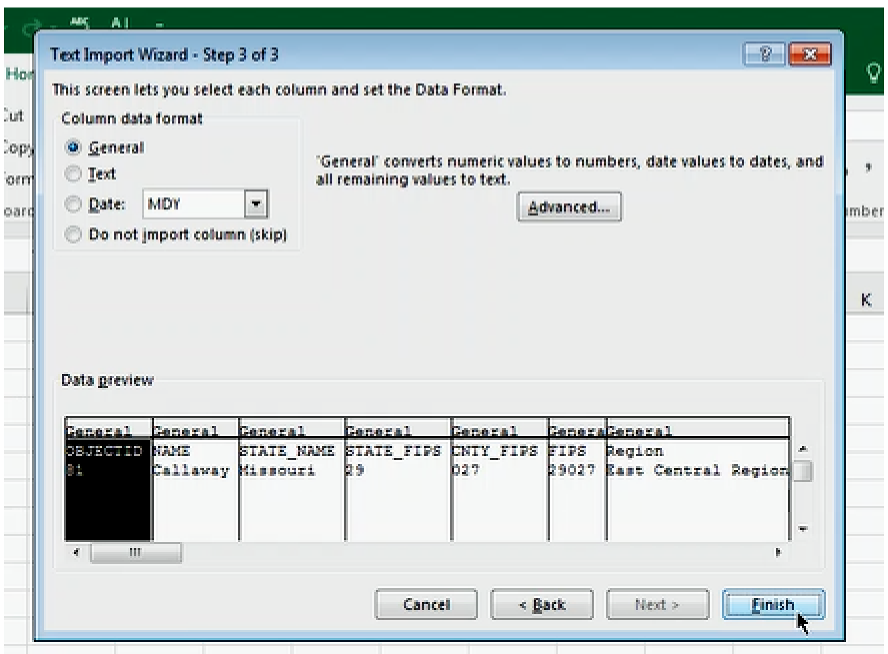




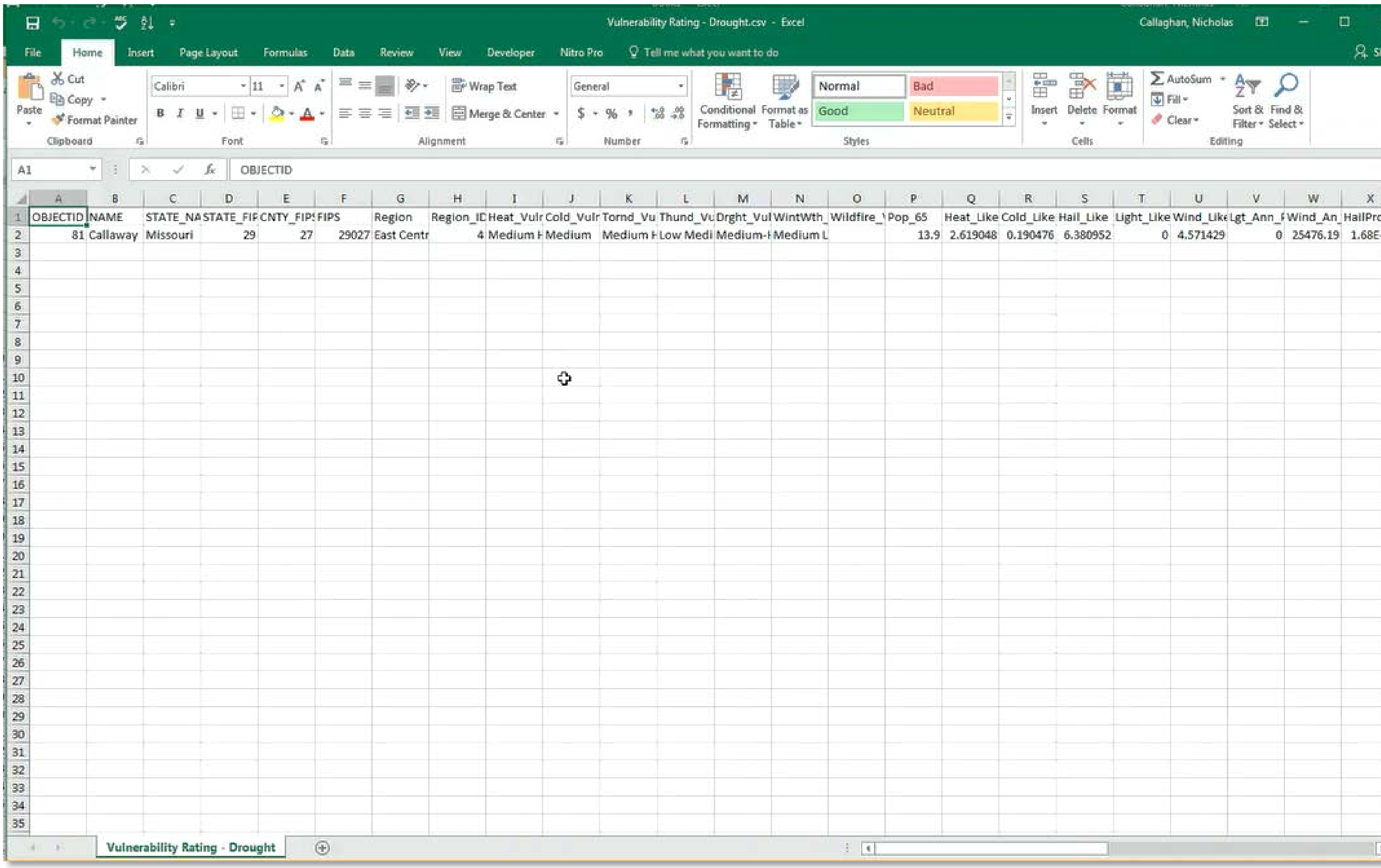
7) The Step 2 of 3 Text Import Wizard Window will open. Select the “Tab” and “Comma” check boxes on the left. Then Click “Next” at the bottom.



8) The Step 3 of 3 Text Import Wizard window will open. Click the “General” radio button on the left. Then click “Finish” at the bottom.

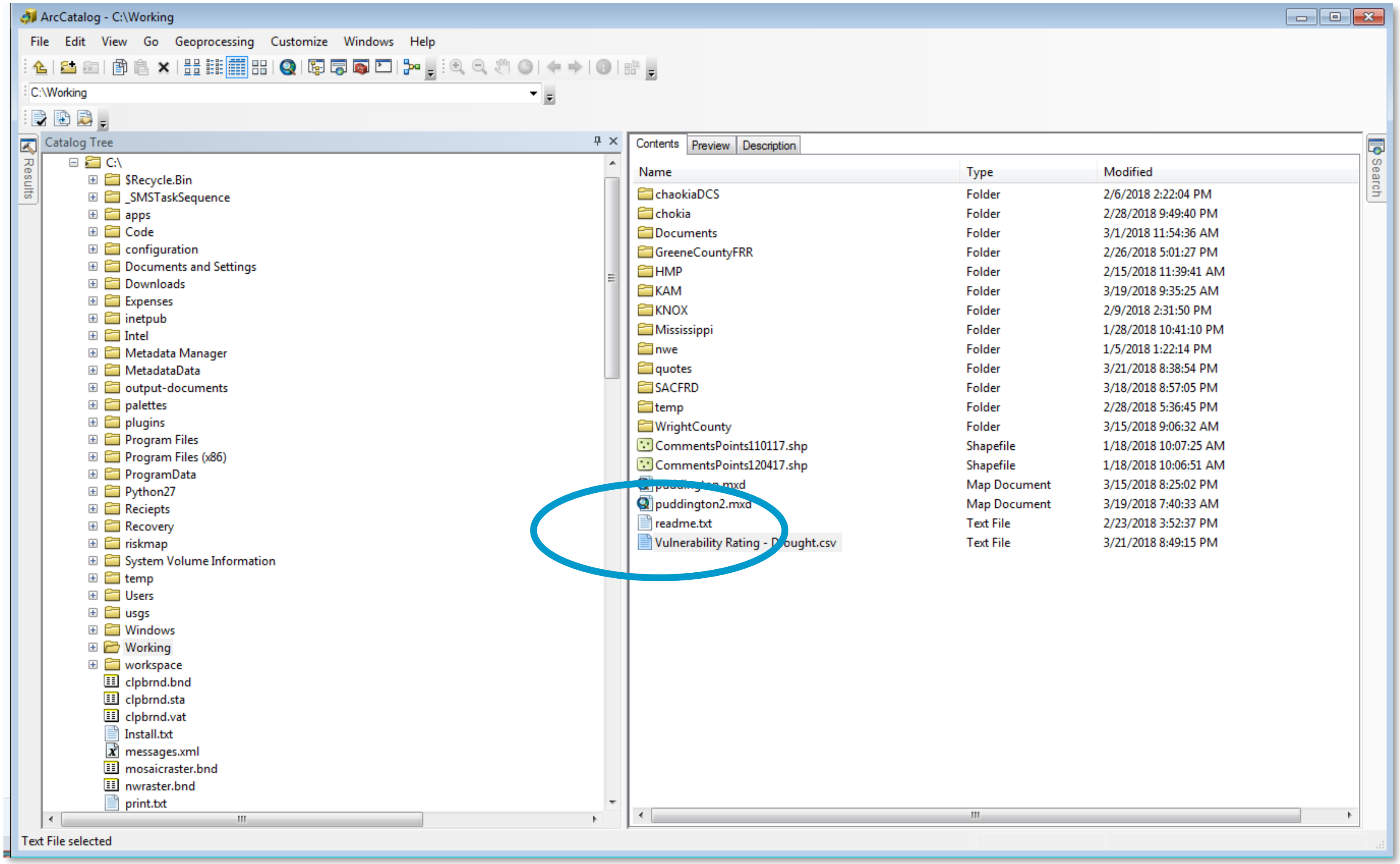


9) The Text Import Wizard window will shut and the data will appear in the Excel spreadsheet.

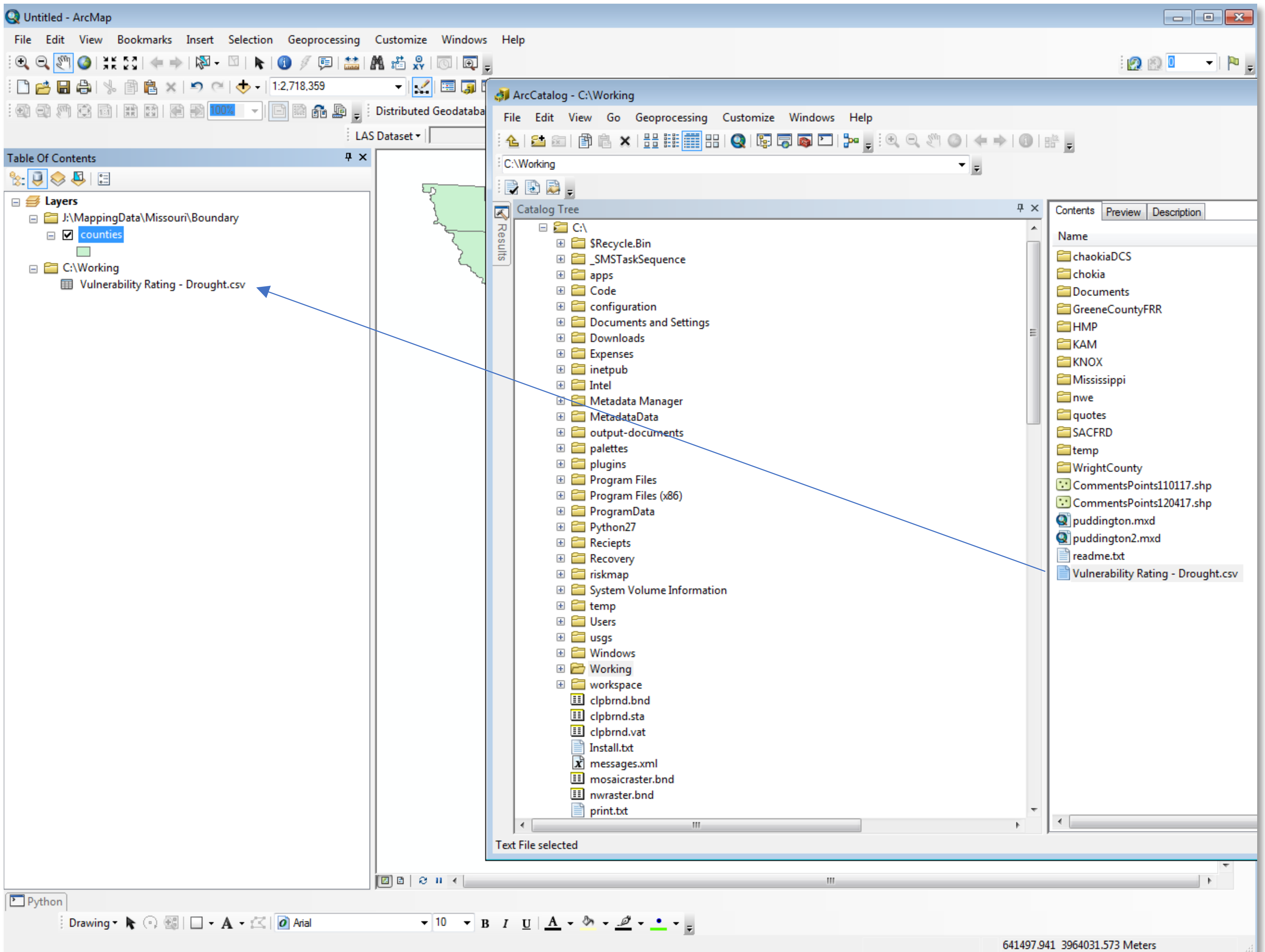


To Open the CSV file in ArcGIS:

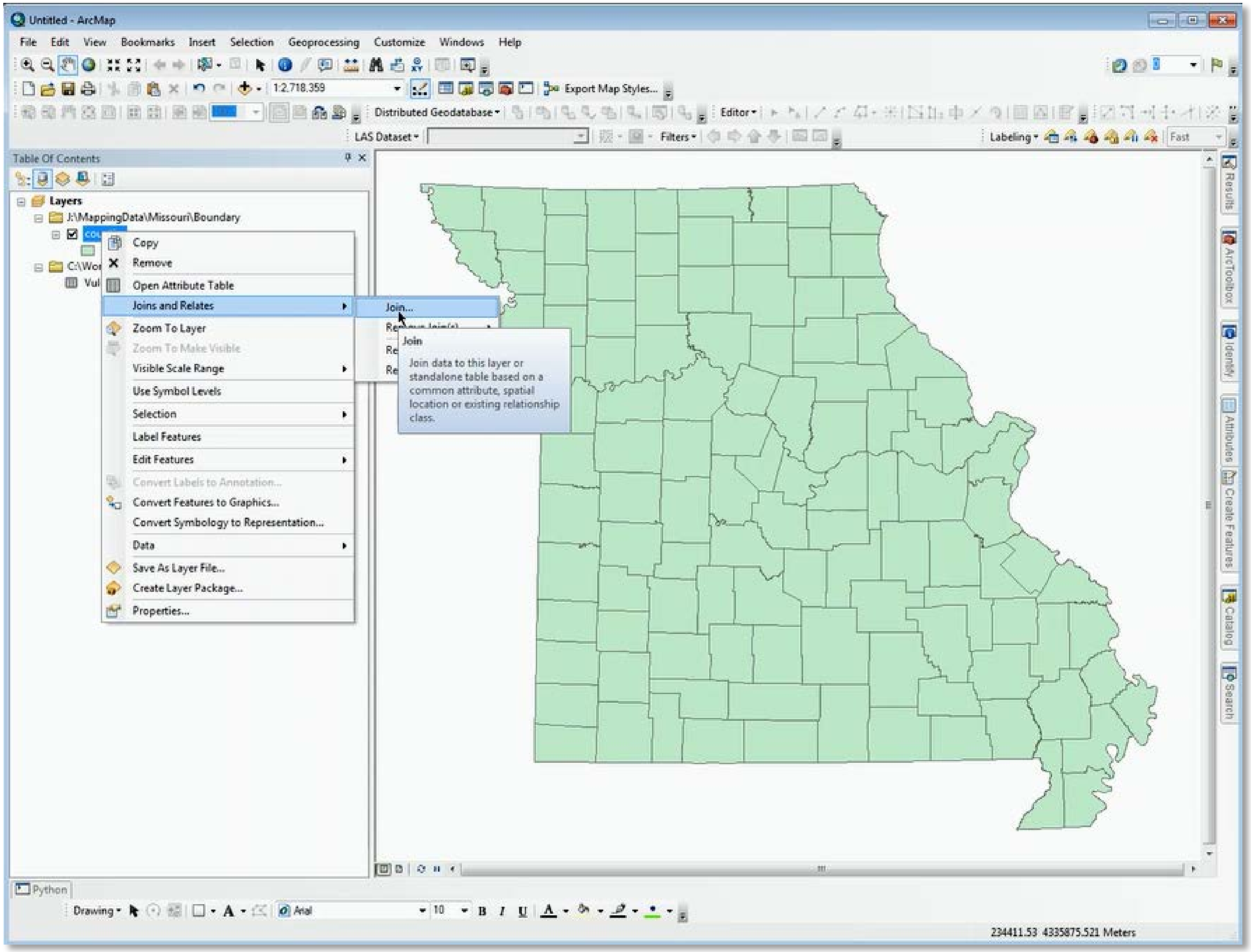
1) Open ArcMAP and then ArcCatalog. Navigate to the stored CSV file location in ArcCatalog.



2) Drag the CSV file from Catalog into ArcMAP. Also add to the ArcMap a county boundary shapefile.



3) Join the CSV file to the County shapefile by right clicking on the County shapefile in the Table of Contents window to open the options window, choosing **"Joins and Relates "**and then **"Join".**



4) A Join Data window will open. Choose the following options utilizing the drop-down arrows:

a) Join attributes from a table

b) Choose the field of the County

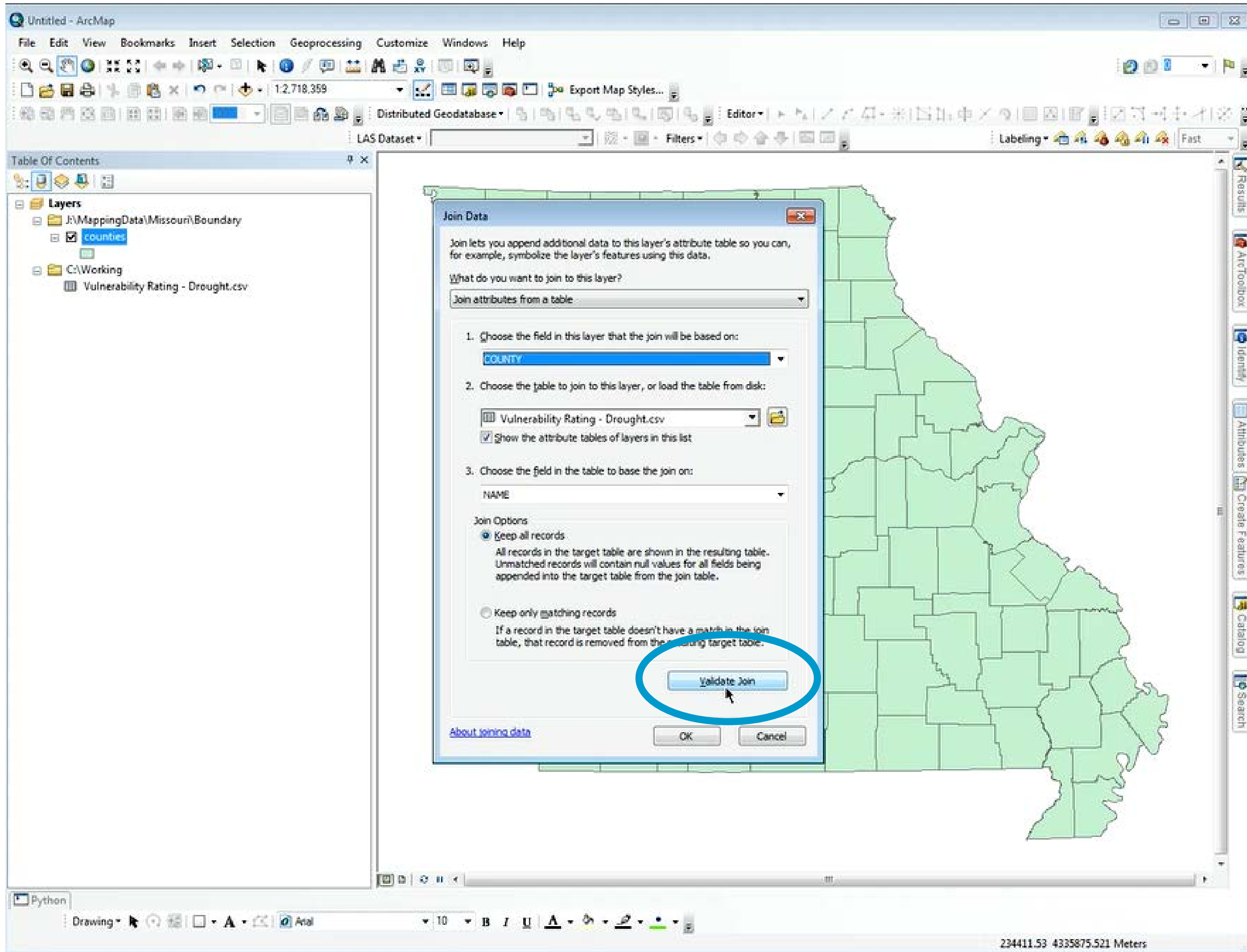
c) Choose the CSV file name

d) Choose the field with the County name in it

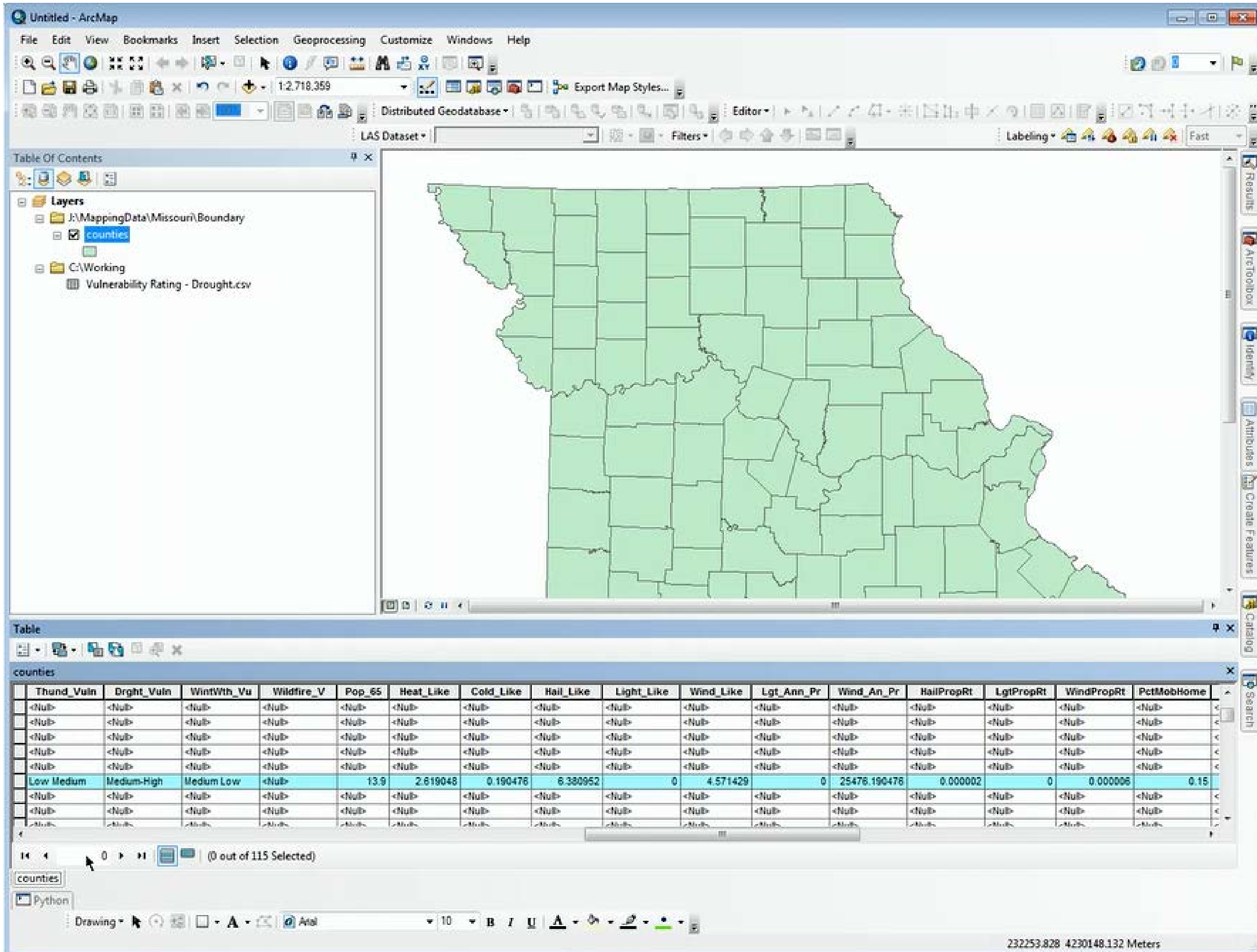
e) Choose "**Keep all records**"

f) Choose "**Validate Join**"

g) Click "**Ok**" at the bottom.



5) The data in the CSV file will now appear appended to the right of the County file attributes. For counties with no data in the CSV file, the attributes are <Null>.



Introduction

Following a hazard event, SEMA mitigation staff can query local officials to document how mitigation actions instituted in the affected areas reduced the amount of damage or loss of life that could have resulted from an event. SEMA has updated this query process and formalized loss avoidance documentation through a newly-developed web-based tool which follows the loss avoidance methodology developed by FEMA.

FEMA developed the loss avoidance methodology to evaluate the effectiveness of mitigation projects based on the analysis of actual events. This methodology can be applied to the mitigation of any type of natural hazard. Losses avoided are determined by comparing the damage that would likely have been caused by the same storms without the project (Mitigation Project Absent, MP_A) with damage that actually occurred with the project in place (Mitigation Project Complete, MP_C). There are three phases of the general methodology for loss avoidance studies:

1) Initial Project Selection
2) Project Effectiveness Analysis
3) Loss Estimation Analysis

Table of Contents

Phase 1 focuses on the selection of the completed project area to be included in the loss avoidance study. Structures are screened based on the availability of data required for completion of the study. This includes actual project costs, construction completion dates, first floor elevations, structure location information, and structure information, including the type, basement information, number of floors, square footage, and building replacement value. Structures with adequate data advance to Phase 2.

Phase 2 includes a storm event analysis, to determine whether a post-construction storm event is severe enough to have caused damage if the project had not been completed (MP_A scenario), and a hazard analysis, to determine the impact of the hazard event (e.g., depth of flooding) at the mitigation project location.

Phase 3 includes two steps. First, an economic evaluation of the project scope is completed for both the MP_A and MP_C scenarios for each hazard event analyzed. The difference between the total losses for the two scenarios is calculated and losses avoided are determined. Second, the return on investment (ROI) is assessed by comparing the losses avoided to the total project investment.

For the 2018 State Plan Update, SEMA has developed a web-based, loss avoidance analysis tool (LAAT) to assist SEMA staff and local officials to collect and store the data necessary to complete a loss avoidance study following a hazard event.

Loss Avoidance Analysis Tool (LAAT) Overview

The web-based, loss avoidance analysis tool (LAAT) is a database of the structural data necessary to complete Phase 1 of a loss avoidance study and is a data collection tool for the storm event data necessary to complete Phase 2 of a loss avoidance study. This is currently for tornado Saferooms and flood buyouts locations. The LAAT website has been merged with the 2023 Hazard Mitigation Plan Viewer and can be accessed here: https://bit.ly/MoHazardMitigationPlanViewer2023 The default landing page is shown below in **Figure 1**.

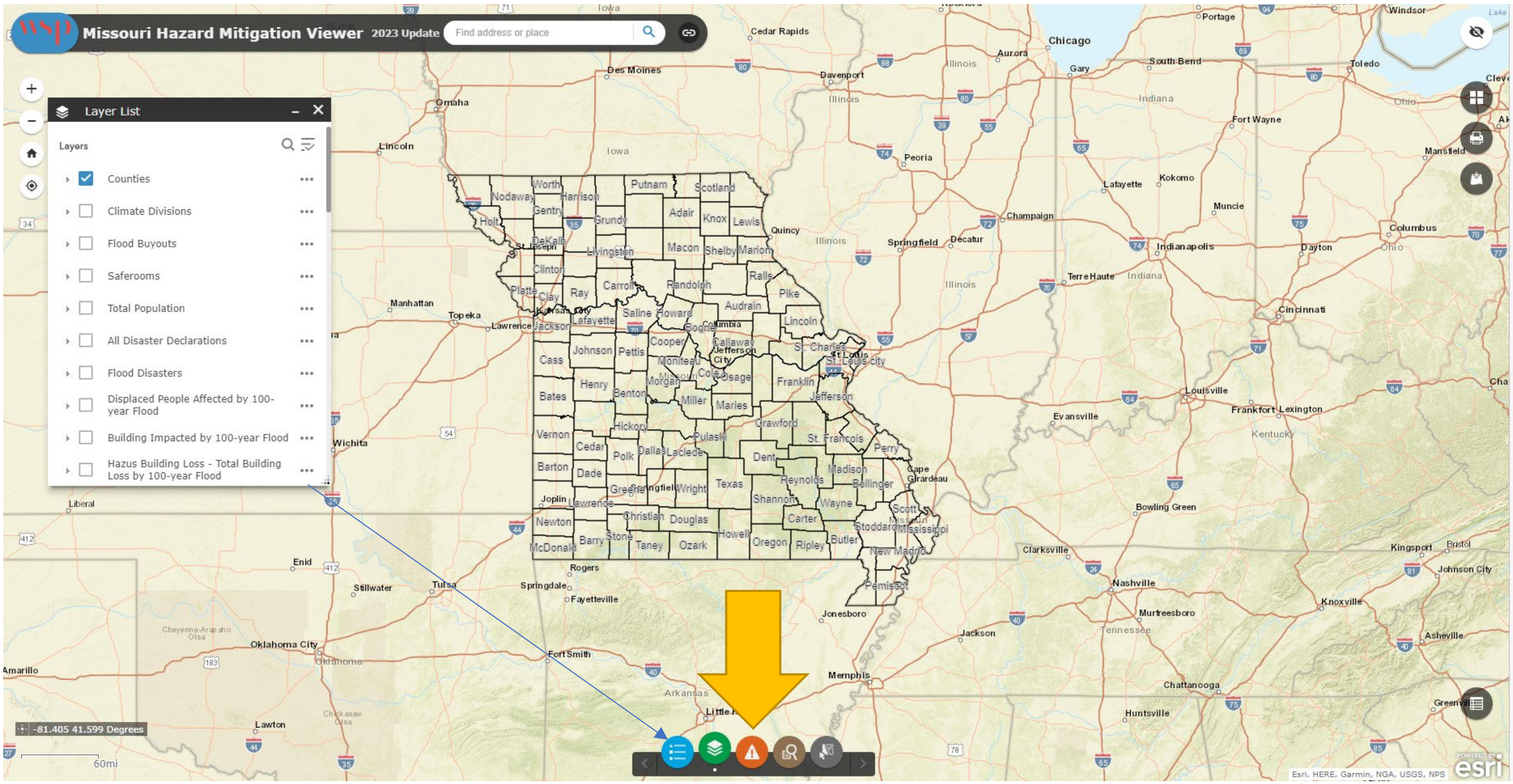


Figure 1: Landing page for the 2023 Hazard Mitigation Plan Viewer

As in the previous version, the LAAT's Incident Analysis can be accessed by clicking on the orange icon in the middle of the page footer, being pointed to with the yellow arrow above. The Layer List can be opened by clicking on the blue icon on the left as indicated with the blue arrow above.

This will cause another footer to appear as shown below, being pointed to with the yellow arrow below in **Figure 2**. The Flood Buyout and Safe Room locations can be turned on in the Layer List by clicking in the box to the left of their name.

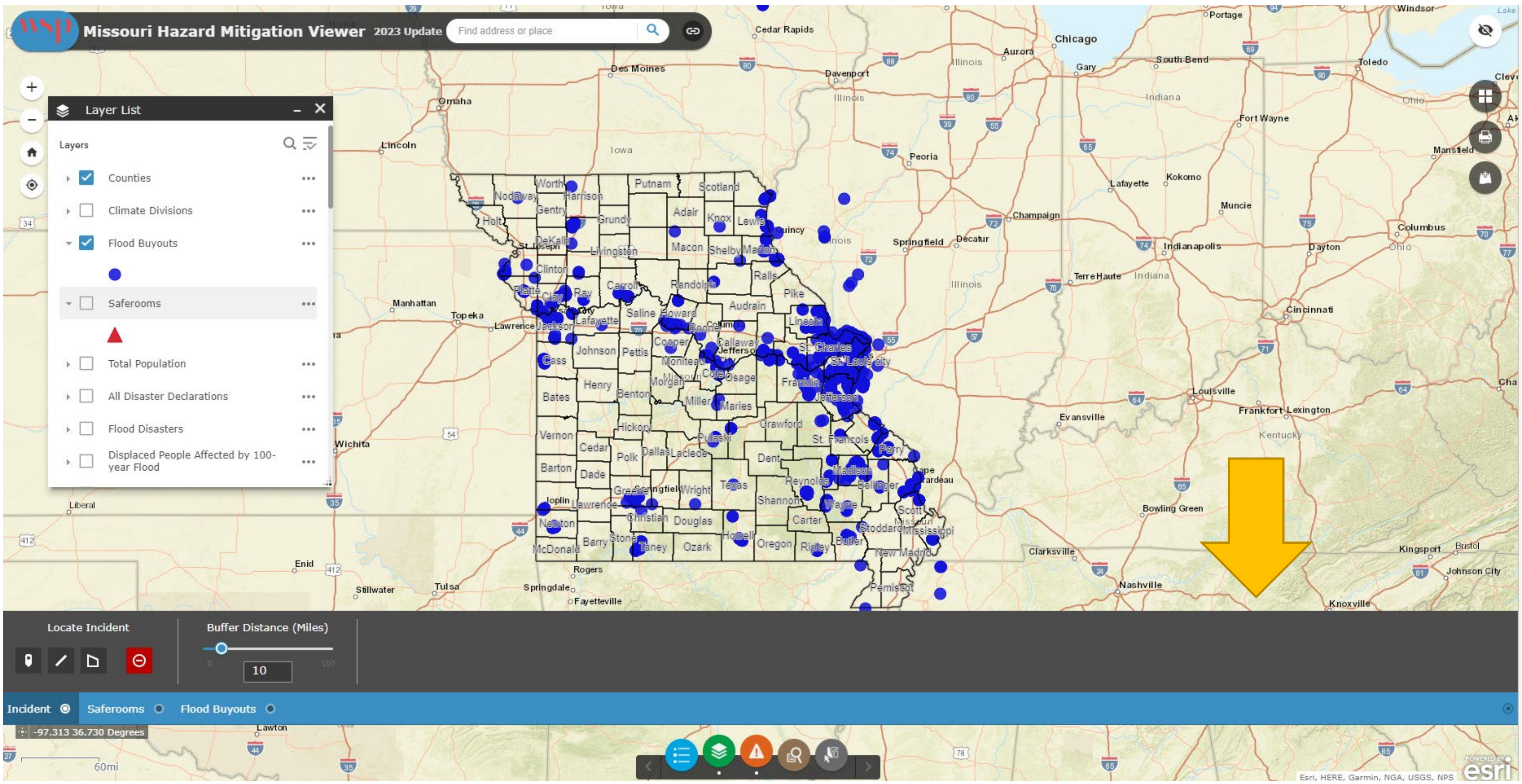


Figure 2: Activation of the LAAT Tool

Step 1: Initial Project Selection – For all completed mitigation projects for Buyout and Saferoom projects within the State, the LAAT database has been populated with project details as included in the approved grant application and project closeout documents. This includes actual project costs, construction completion dates, first floor elevations, and structure information where it was available. Not all locations have all the information. The FEMA Corps improved the latitude and longitude data for each acquisition site, at the time of the 2018 State Mitigation Plan Update. This data has been incorporated into the LAAT. **Figure 3** presents the LAAT website showing the tornado safe room locations in red and residential buyout locations in blue.

Each mitigation project has also been spatially located based upon the street address or latitude/longitude, as either obtained from the project grant application or field located with GPS. Efforts to map completed buyouts prior to 2002 have proven difficult because communities have combined parcels and lots into combined open spaces, streets and addresses no longer exist (as a result of the buyouts).

Those mitigation projects with limited structural or location data are included in the LAAT database, but should move forward to Phase 2 with an understanding of the known deficits before being utilized in a loss avoidance study.

The LAAT database may be updated at any time to include additional project information. For future mitigation projects, the structure data necessary to complete Phase 1 of a loss avoidance study will be entered by SEMA staff upon project completion and closeout.

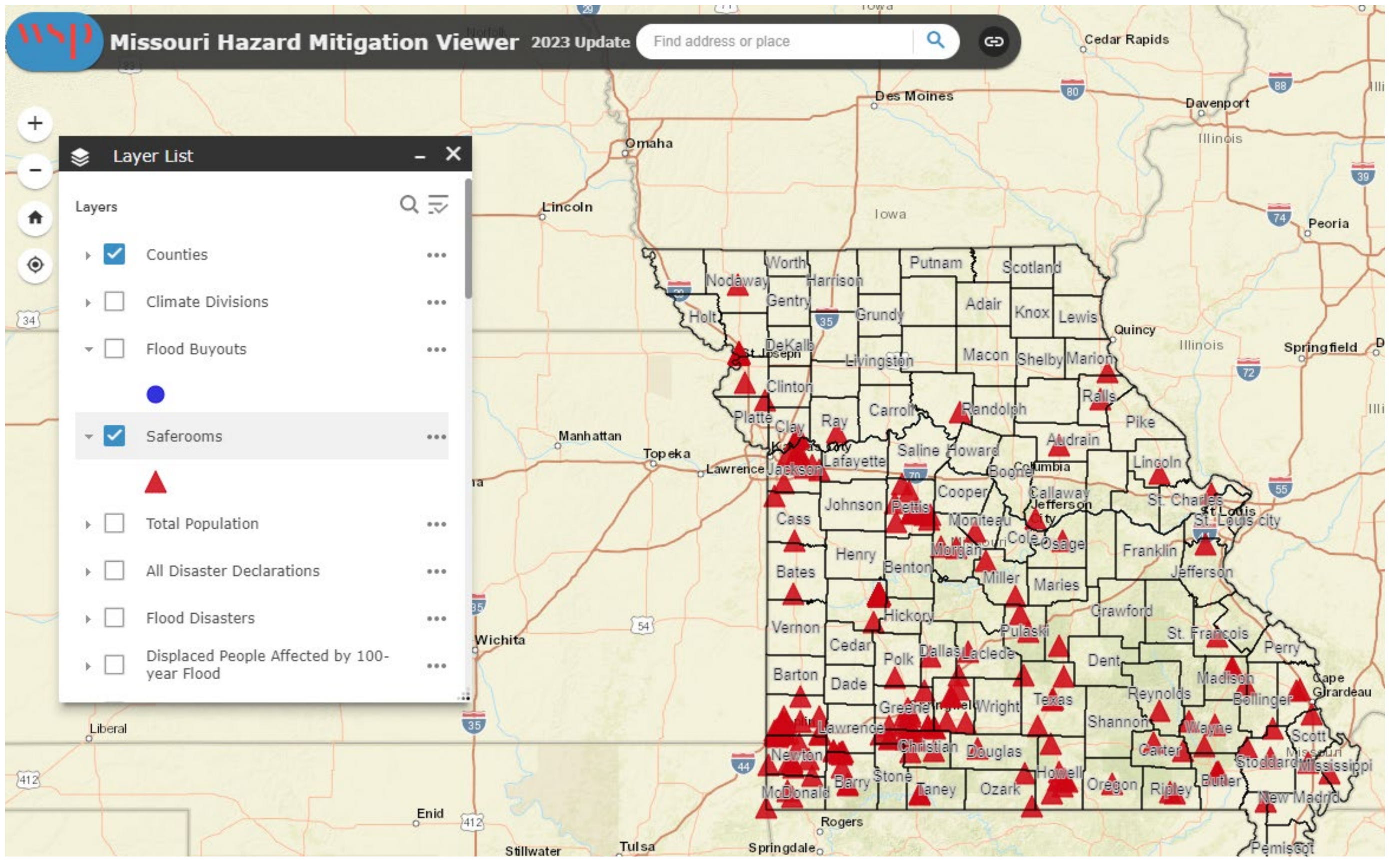


Figure 3: Safe Rooms shown on the LAAT Tool

Step 2: Project Effectiveness Analysis – Because a loss avoidance study measures benefits of a completed project based upon an actual event, the local official will be tasked with completing the storm event data collection form following a hazard event within their community or SEMA staff can add this information easily to any reports resulting from disaster declarations. The user can spatially select those mitigation projects within the hazard event area and do a simple export to show the calculated loss avoidance. **Figure 4** displays the Operational Tools available on the website using the icons along the bottom of the page. **Figure 5** shows a close up of the Add Data Tool options that is found on the right side of the page. Also shown with the yellow circle in Figure 4. Users can either upload a project area shapefile or simple draw an area of interest to use for the analysis as shown in **Figure 6**, respectively. The user can also share the data from the analysis with others as shown in **Figure 7**.

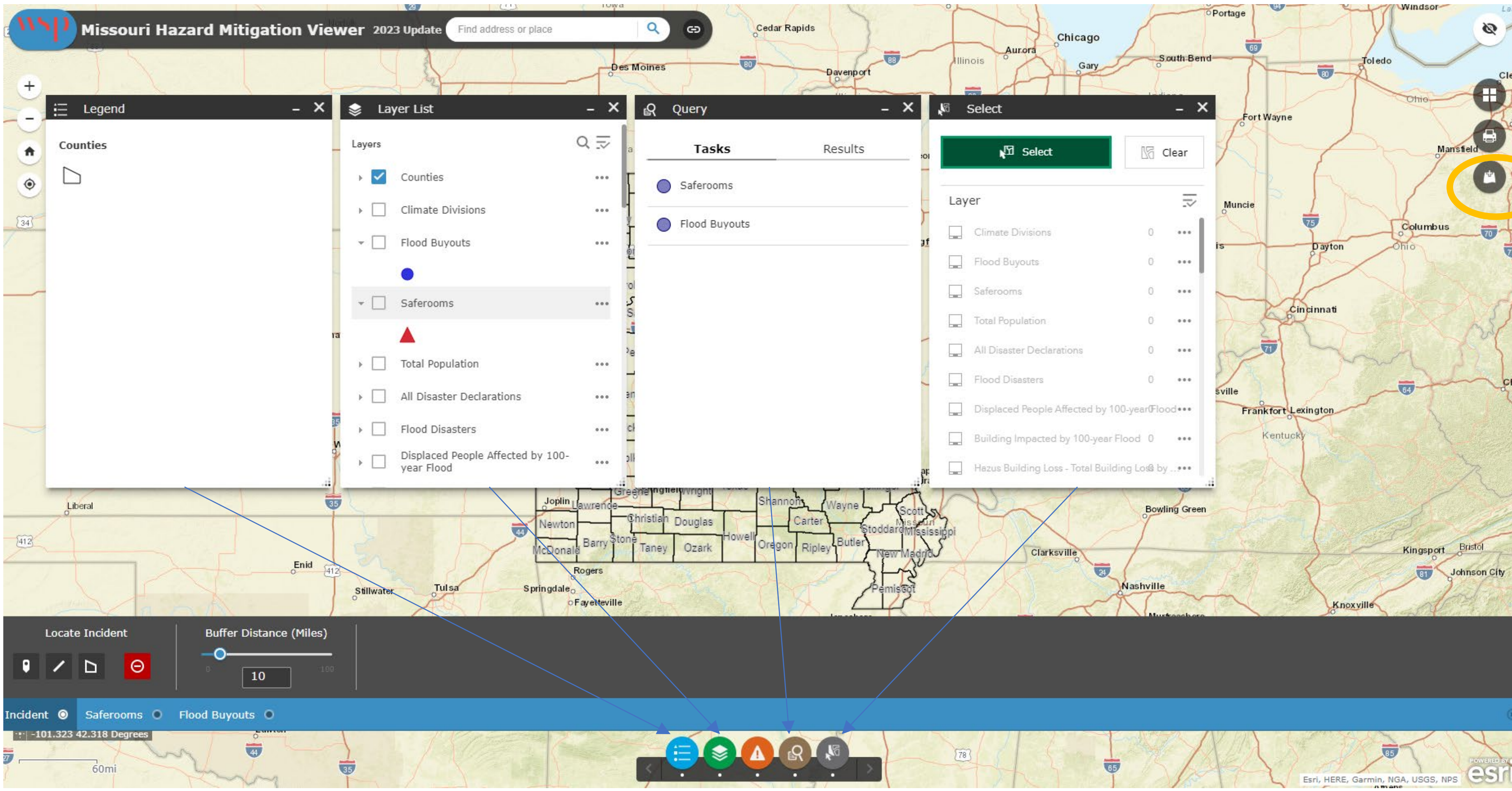
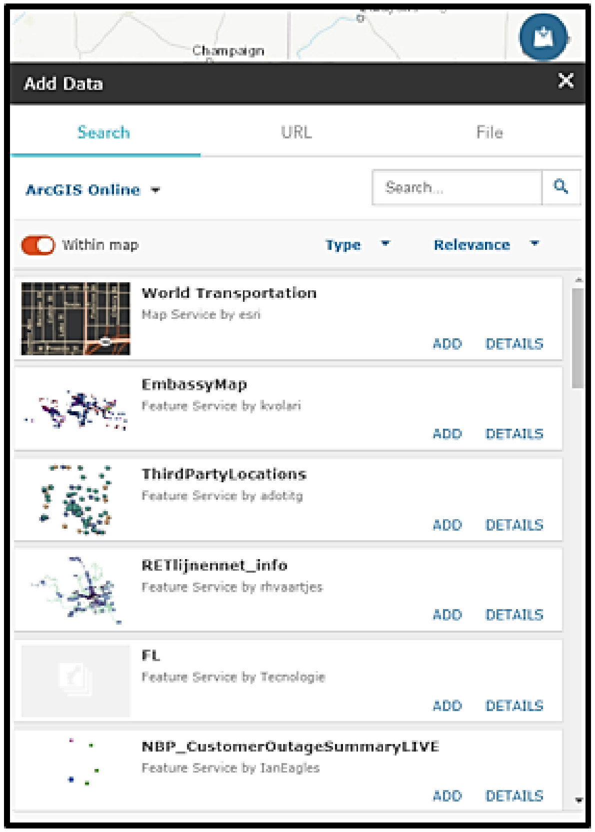
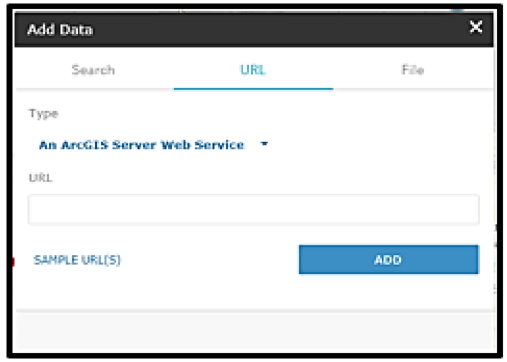


Figure 4: LAAT Operational Tools

1) From ArcGIS Online



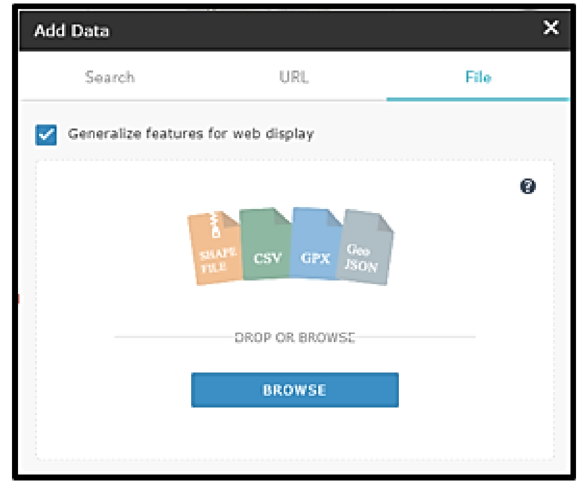
2) From another Public Location/Agency



Add Data from following:

- ArcGIS Server Web Service
- WMS OGC Web Service
- KML
- GeoRSS File
- CSV File

3) Project and/or Personal Data



Add Data from Local Computer by Drag/Drop or Browse to Location.

Files Include:

- Shapefile
- CSV
- GPX
- GeoJson

Figure 5: The "Add Data" Tool

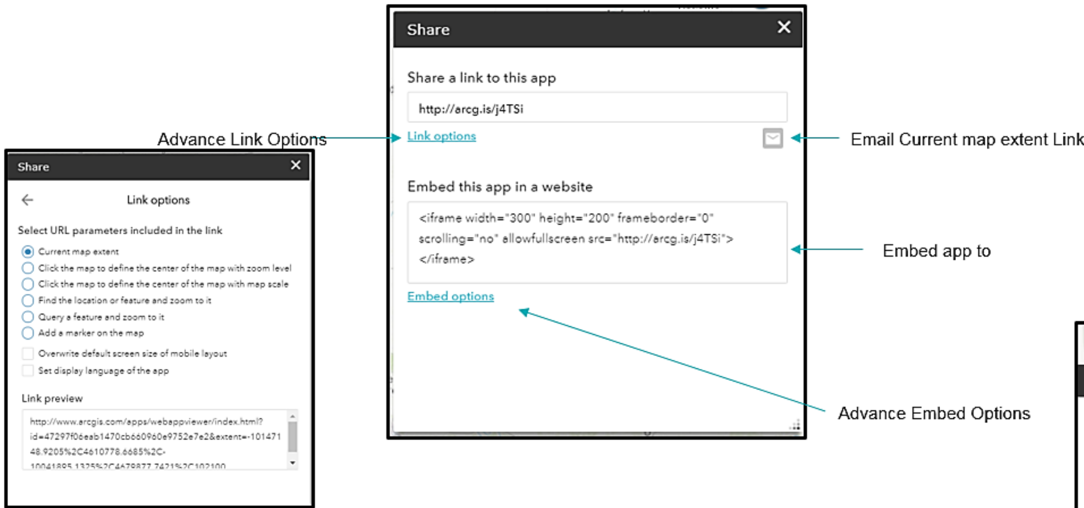


Figure 6: The "Draw" Tool

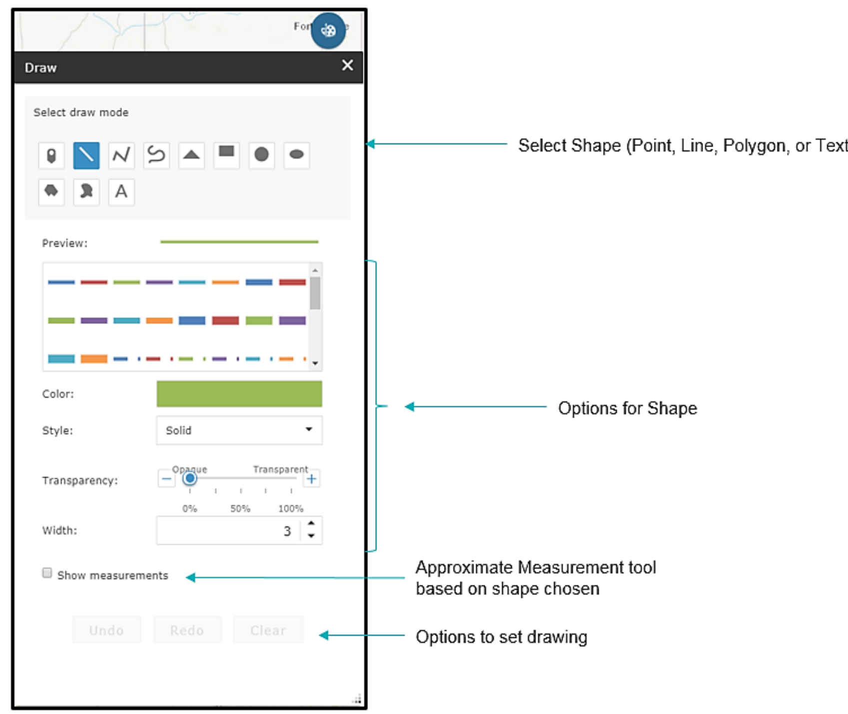


Figure 7: The "Share" Tool

Step 3

Step 3: Loss Estimation Analysis - This final phase consists of estimating losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. The two major tasks in Phase 3 are (1) calculating losses avoided and (2) calculating the return on investment. This can now be done “on the fly” with the LAT by utilizing the Query Tool as shown in **Figure 8**.

This information and the results of completed loss avoidance studies will be incorporated into mitigation success stories to aid in the assessment of the current and future goals, objectives, and actions by simply exporting the data in the needed format using the Incident Analysis Tool shown in **Figure 9**.

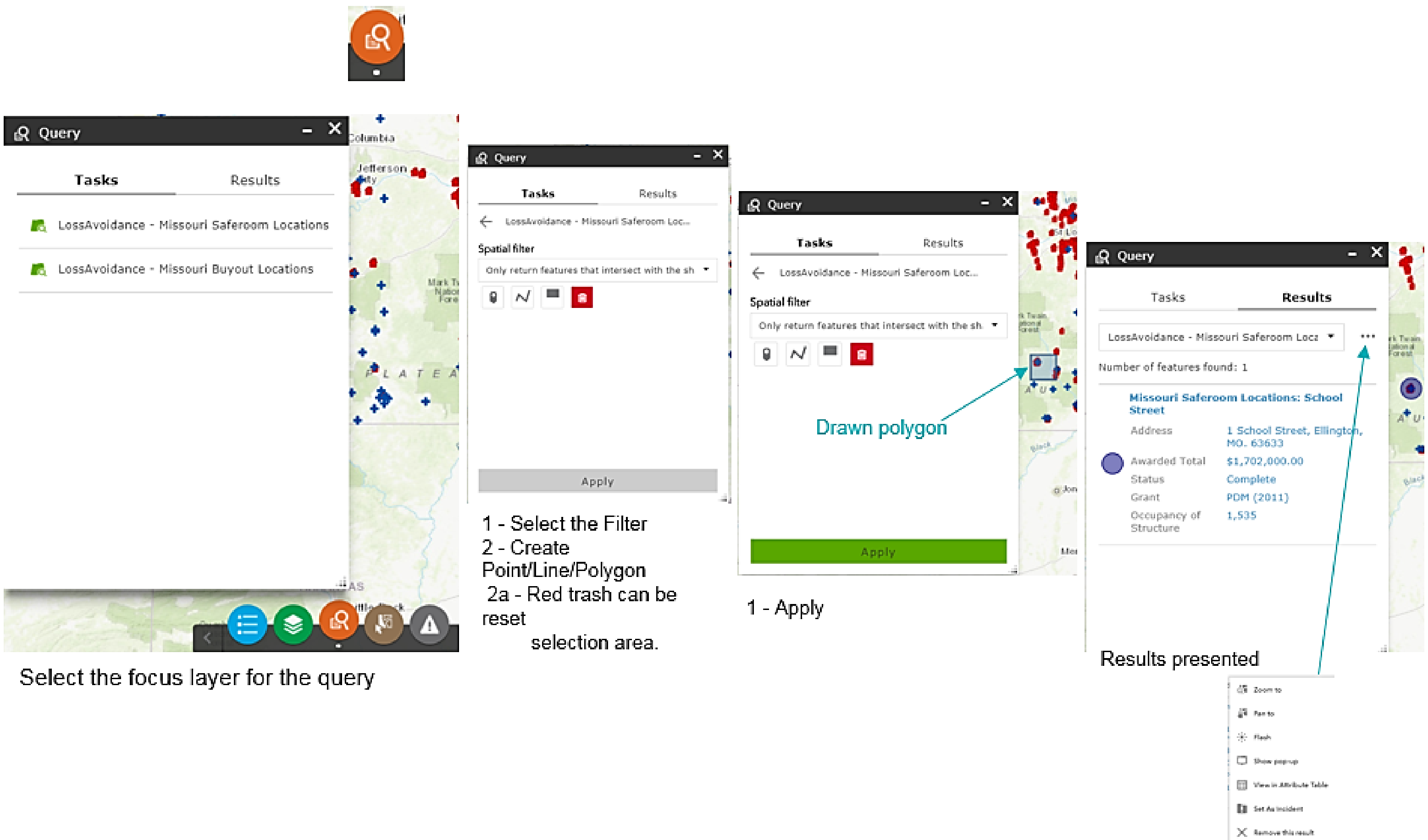


Figure 8: The "Query" Tool

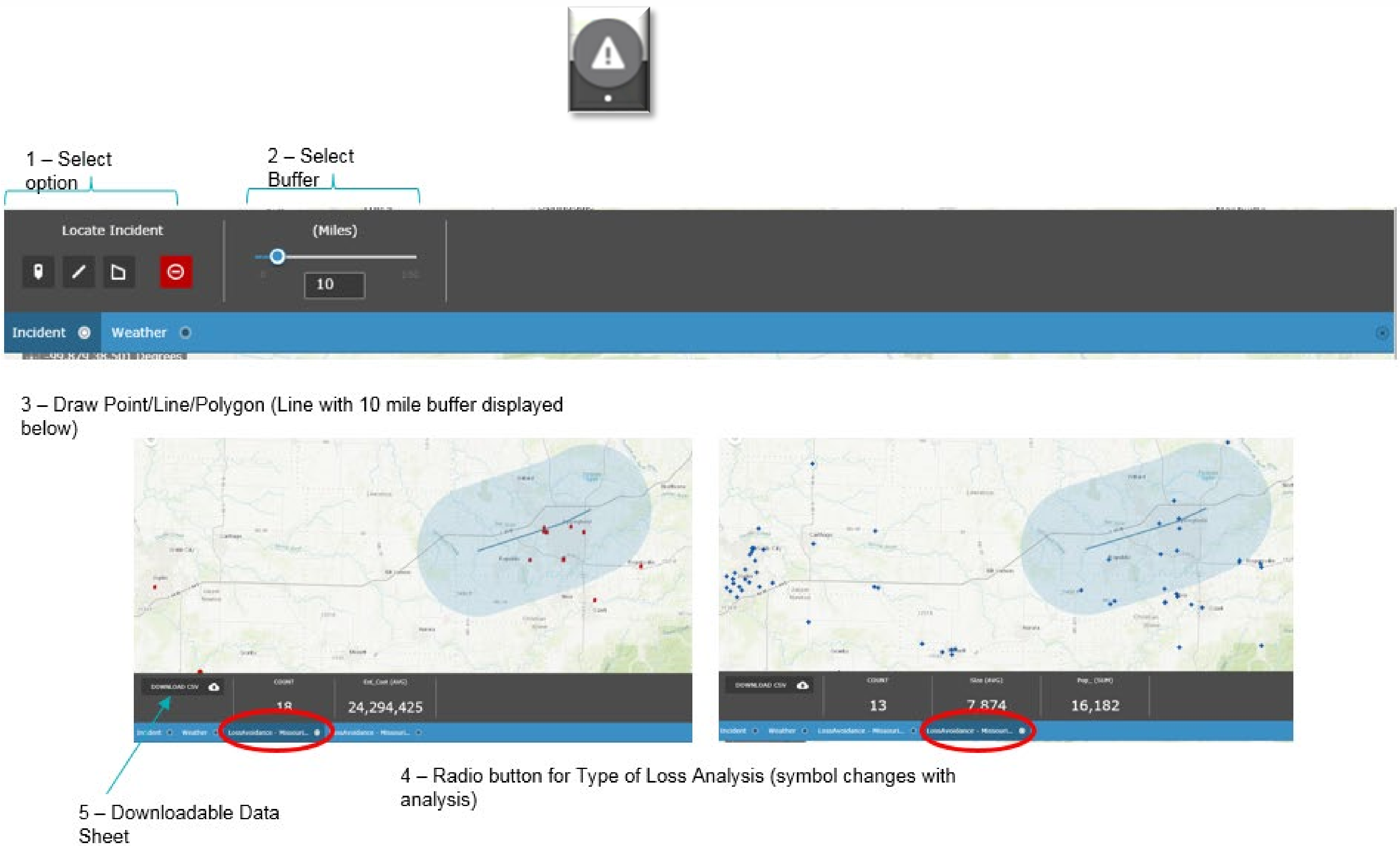
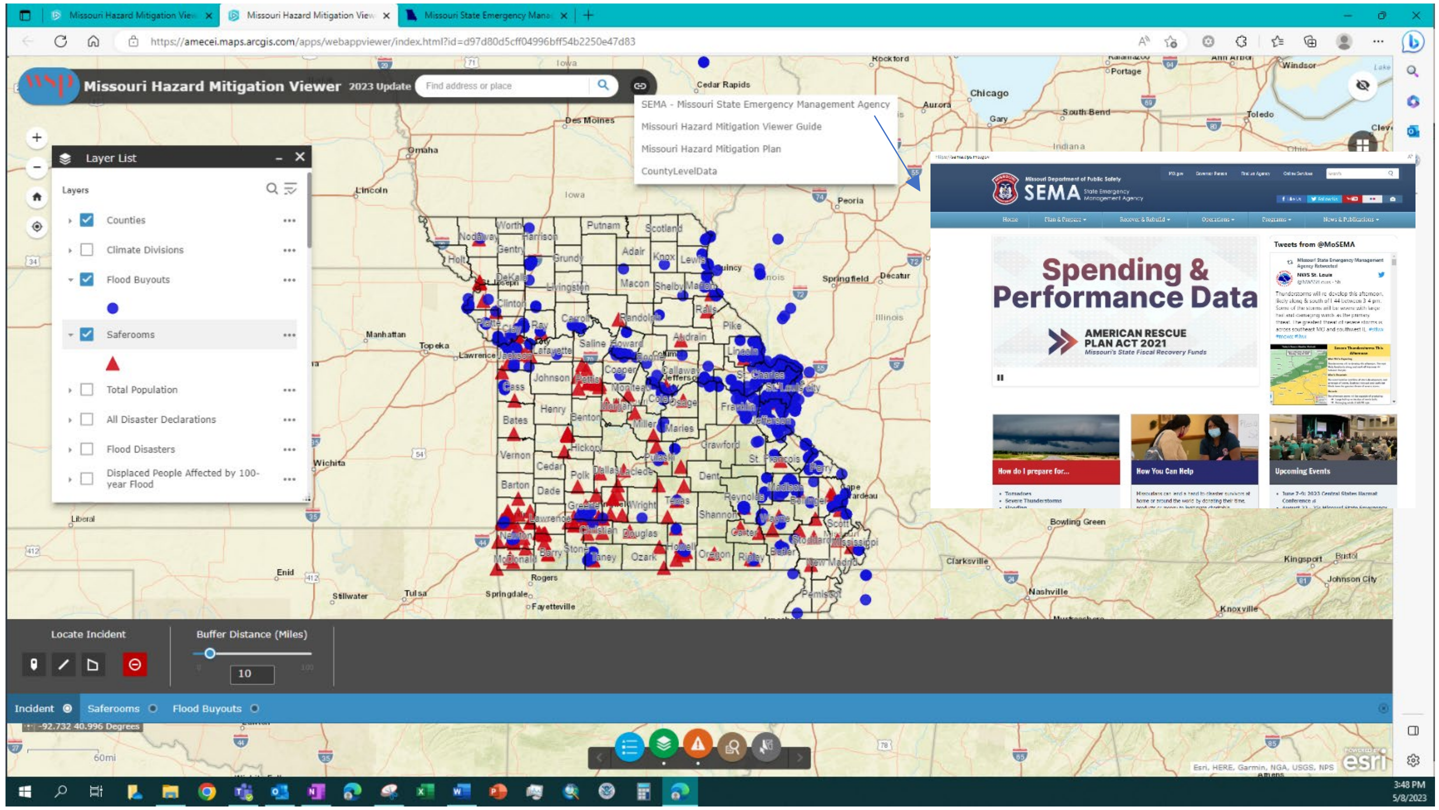


Figure 9: "Incident Analysis" Tool

The initial screen looks like this. The chain link in the top banner is a link to the SEMA website.

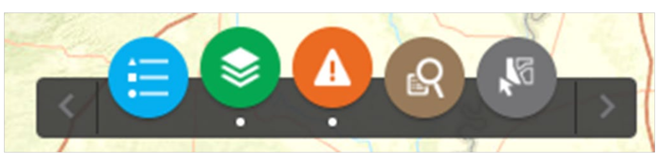
Use the + and – buttons in the upper left of the screen or the Mouse wheel to zoom in and out.



The Home or Full Scale button will zoom to the state and center it in the screen.

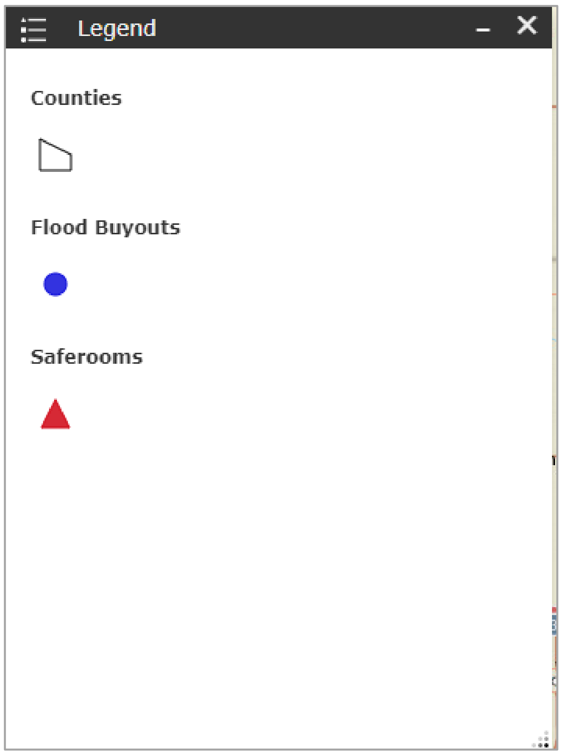
Use the Full Screen button in the upper right of the screen to make the website take up the entire screen on the window. When activated it changes to look like the button on the right. It is a toggle, so click it again to go back to normal screen.

The Attribute button in the bottom right of the screen can be clicked to view the attributes associated with the layers in the map.

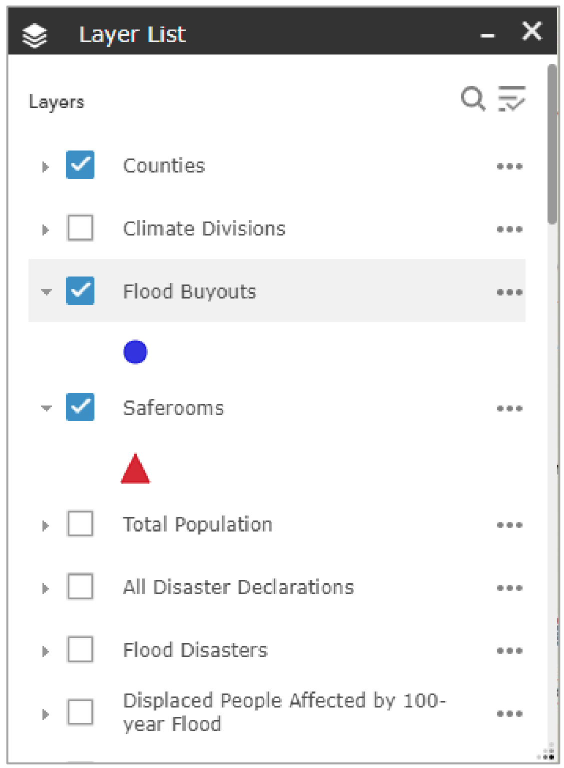


At the bottom of the page is a banner with five tool icons. From left to right they are the Legend, the Layer List, the LAAT Tool, the Query and the Select tools. The following pages describes each icon.

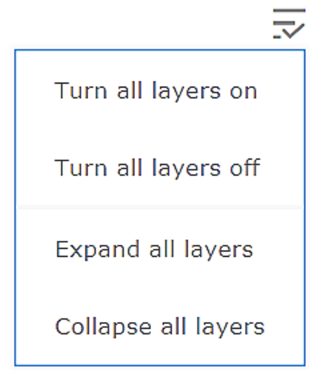
 The blue one is the Legend icon. Clicking it will open a window explaining the symbology (symbols and color) of the active layers.



 The green one is the Layers List. Clicking it will open a window indicating what Operational layers are in the map. The blue check marks indicate the layer is turned on, the empty checkbox indicates they are turned off. These are toggles and the layers can be easily activated/deactivated by clicking inside the checkboxes.

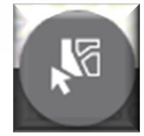


 This icon in the upper right of the Layer List, when clicked will open to show options to turn on/off all layers and expand/collapse all layers.

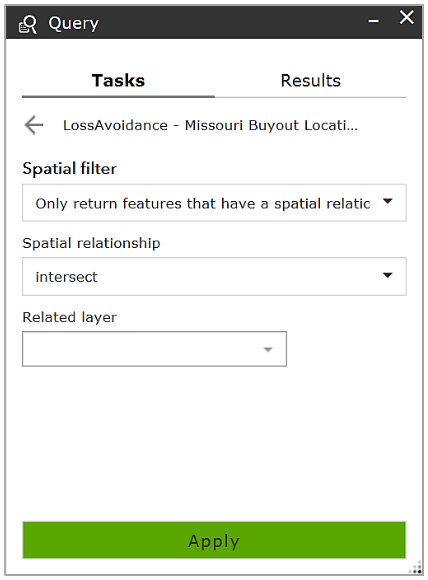


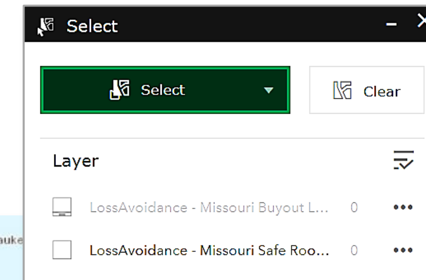
The brown one is the Query Tool. Clicking it will open a window to use in User Analysis. This functionality will be described more in Example #1 below.

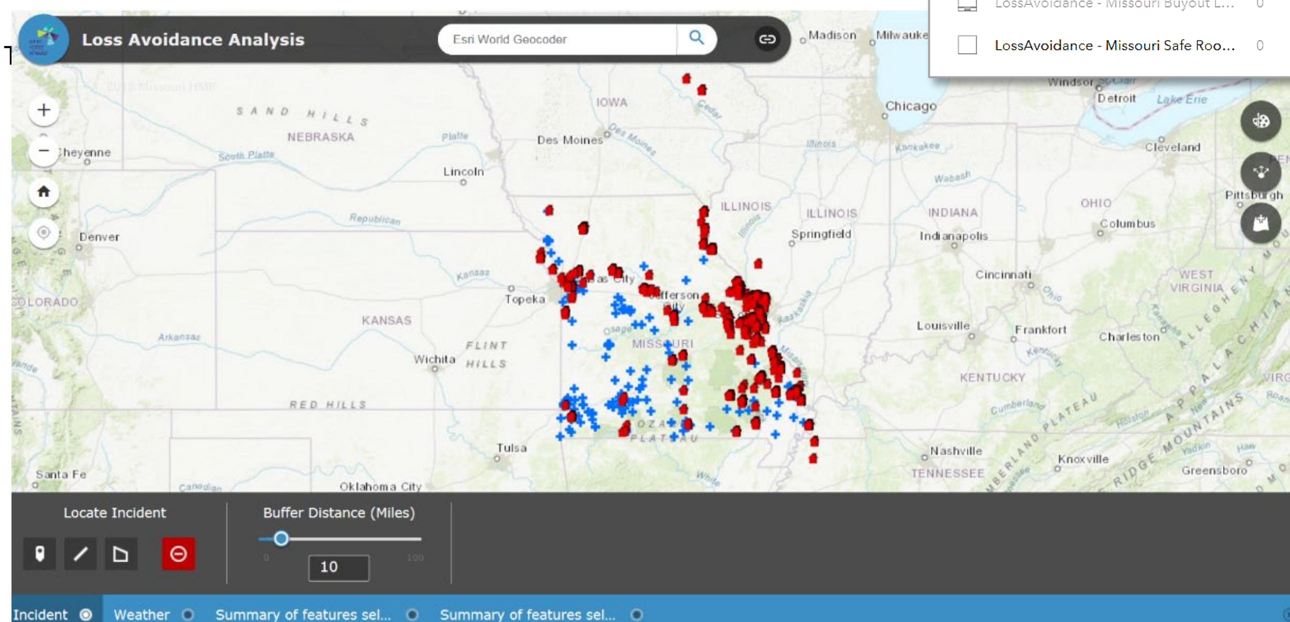
Orange one is the Incident Analysis Tool. Clicking it will open a ribbon across the bottom of the screen. Using it will be described in more detail in Example #2 below.



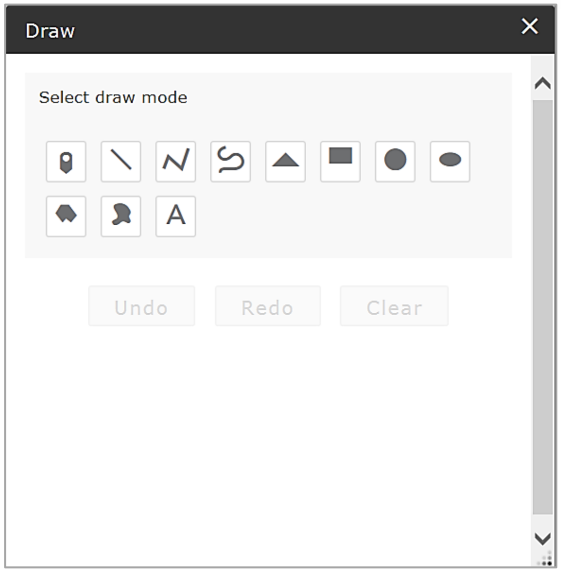
The gray one is the Select Tool. Clicking it will open the Select window to allow the user to select certain points of interest in either the Buyout locations or the Saferoom locations. More description of how to do this can be found in Example #3 below.



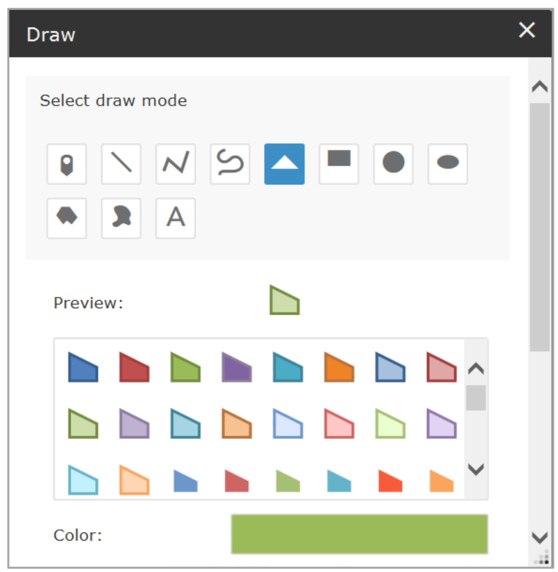


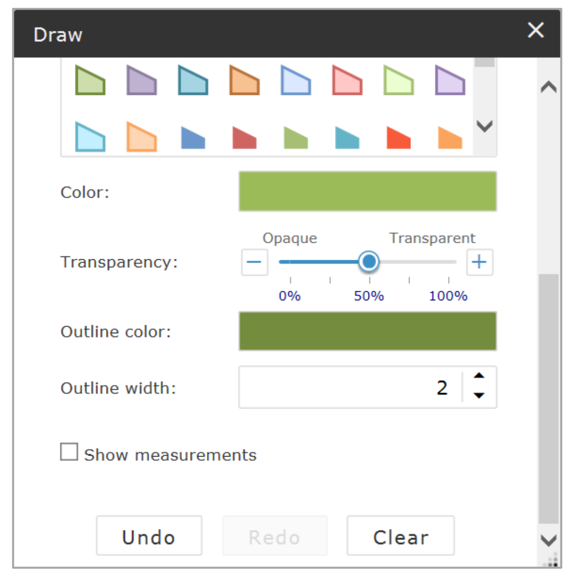


Clicking on the **Draw tool** in the upper right of the screen will activate this window.

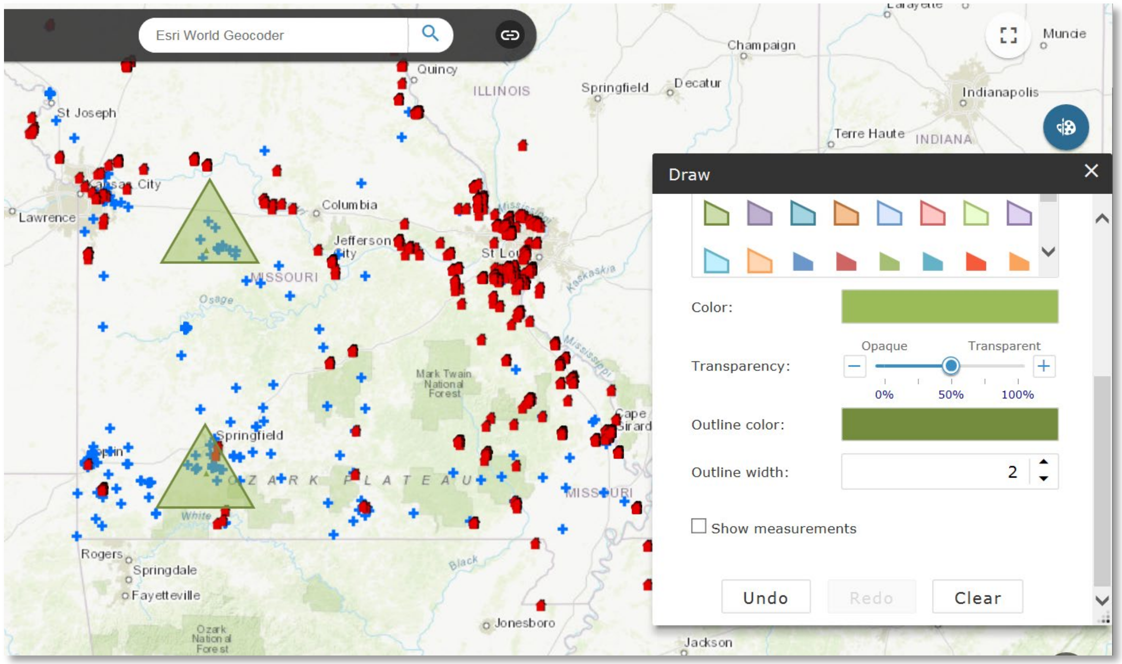


Clicking on any of the **draw mode icons** will activate a preview window with color selections. Use the scroll bar on the right to see more options to customize the color, transparency, outline color and width. Using "Undo" erases the shapes in order of creation, "Redo" will add them back in order of creation and "Clear" will erase all of them.

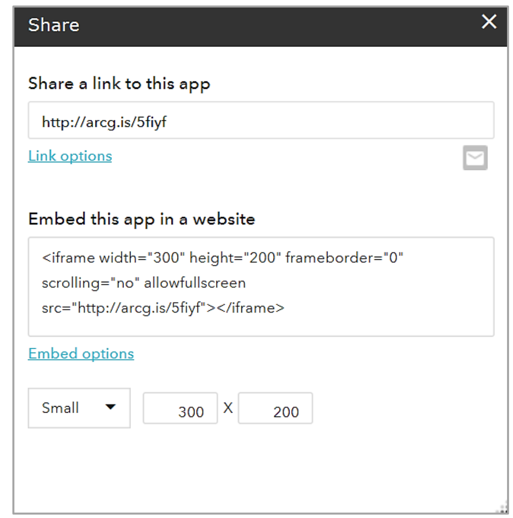




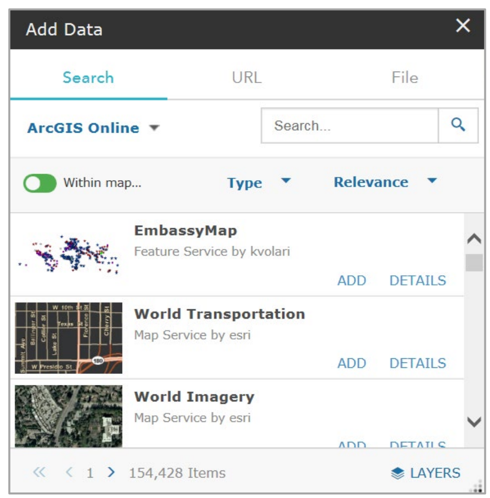
This function can be used to show areas of interest on the map which can be printed or saved as a pdf for future reference.



The "**Share**" button in the upper right of the screen opens the Share window giving the user the ability to share the map with others or embed the app in a website. Clicking the envelope button on the right of the window will open an email using your default email account with the link in it.



To **Add Data** for analysis, click this icon in the upper right of the screen and the Add Data window will open. Data from web services or user input can be added here.

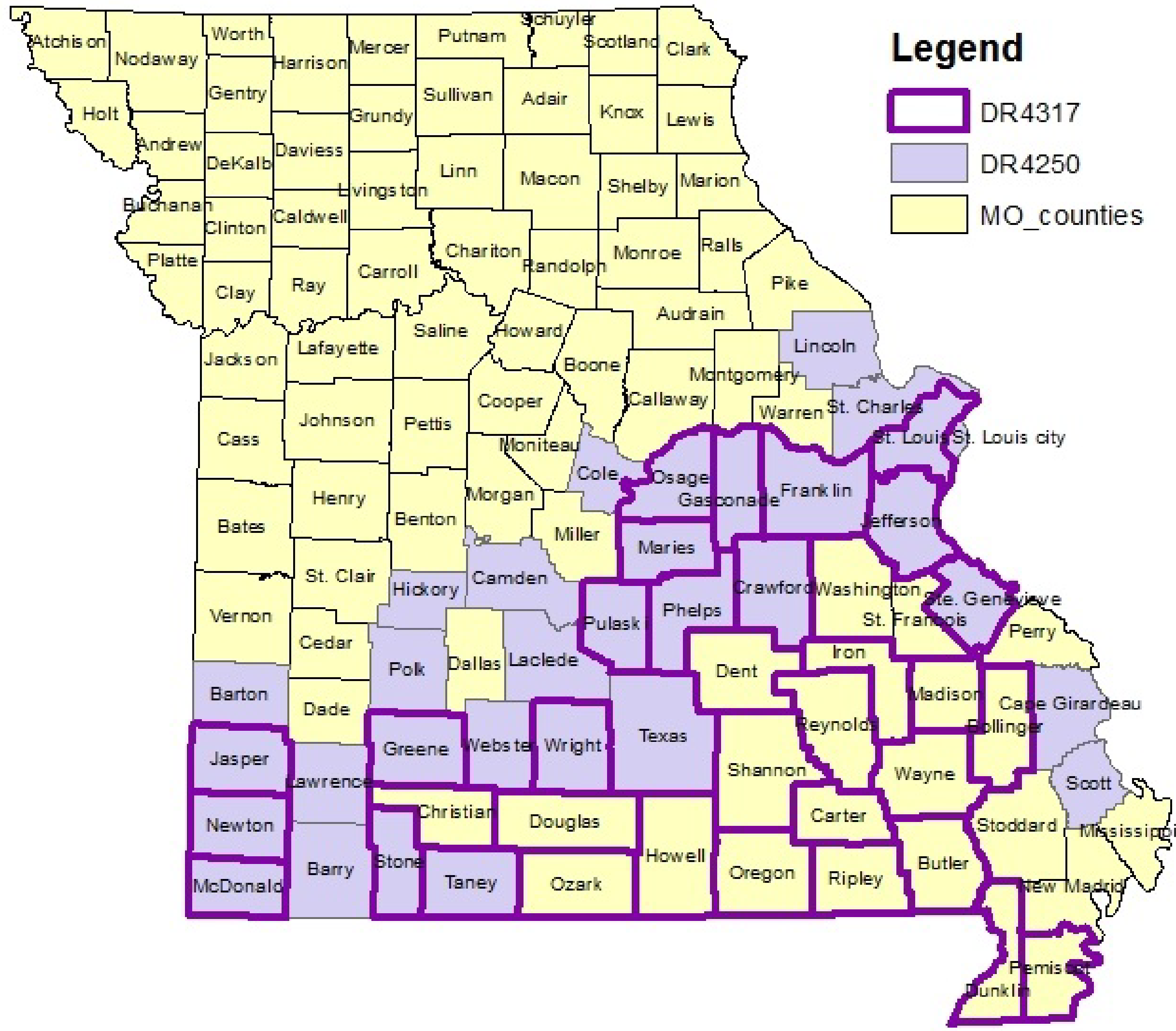


Example #1

The following is a Specific example using the LAAT for additional DR-4250 and DR-4317 for the Buyout Locations Disaster wide.

Preparation

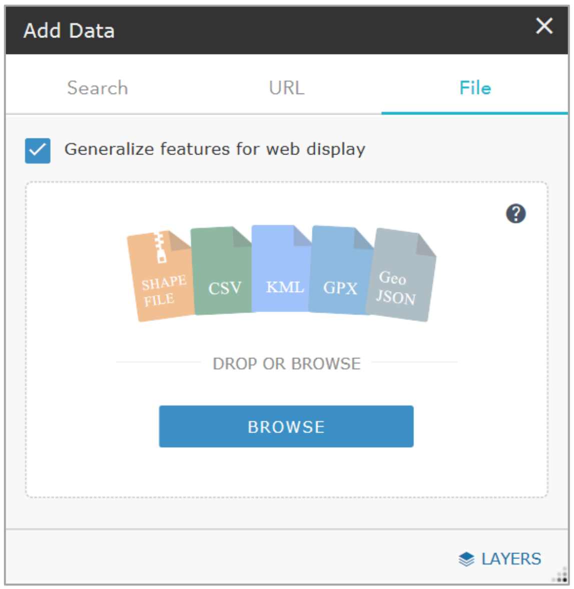
The input used is a list of the affected counties for each disaster declaration. Two shapefiles of the two disaster declared areas were used in this first example. The graphic to the right shows the affected areas.

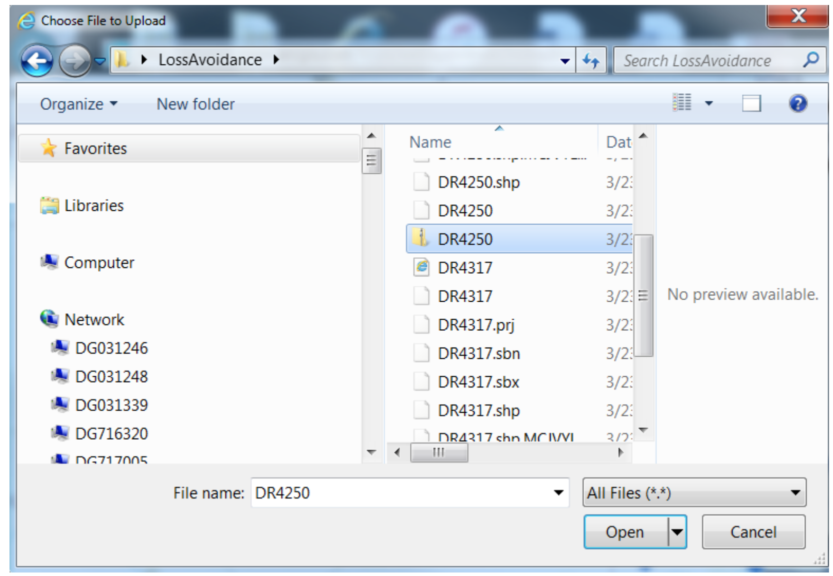


Log into the LAAT website at https://bit.ly/MoHazardMitigationPlanViewer2023

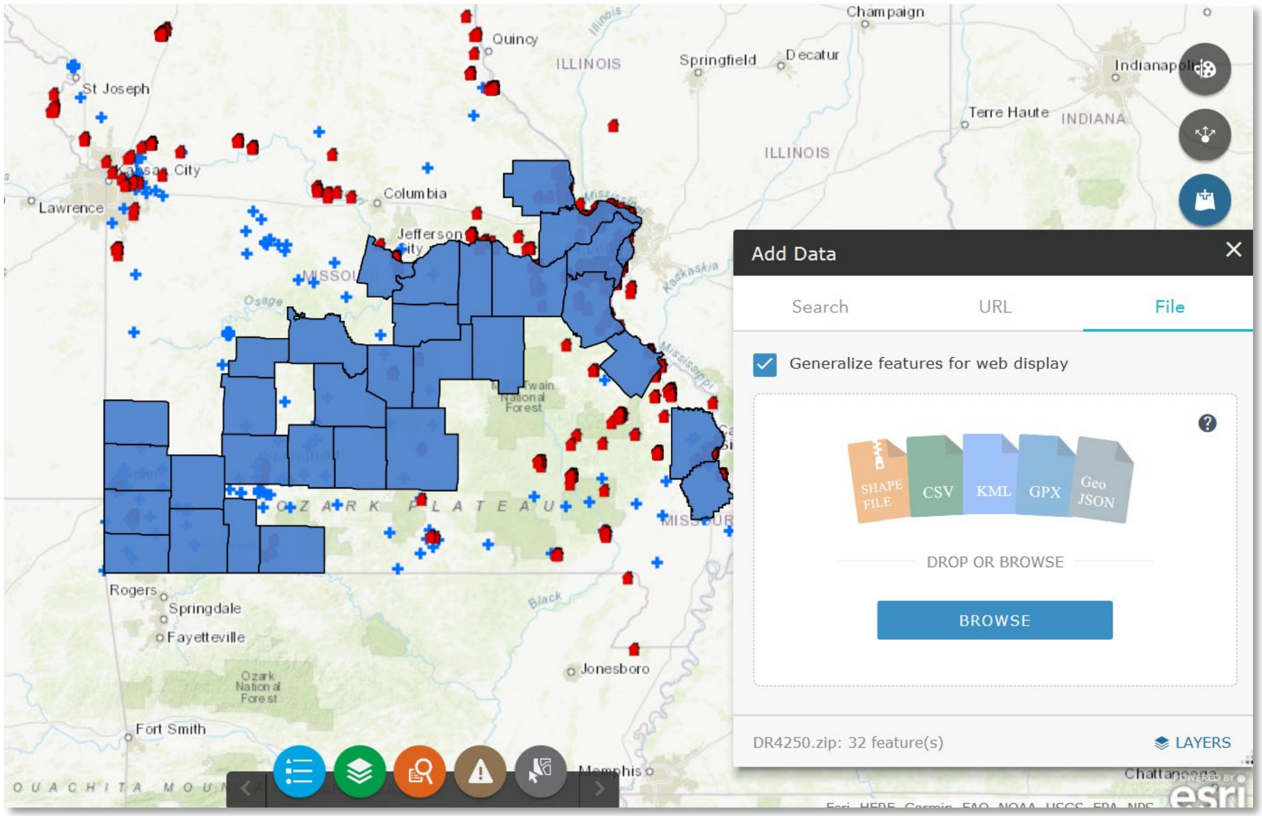
In this example, we'll add the affected areas for DR4250 first. Click on the File tab. The user can either drag and drop a file or can navigate to it using the Browse button. Shapefiles, CSV, KML, GX or GeoJSON file formats may be added. If you click Browse, then another window will open for navigation. Note that shapefiles will need to be zipped for this function. Ensure that any locks on the shapefiles are not included in the zipping. Click "Open" and the website will unzip and display the files as shown in the graphic on the next page.

Each of the windows for Draw, Share and Add Data can be closed by clicking the X in the upper right corners.

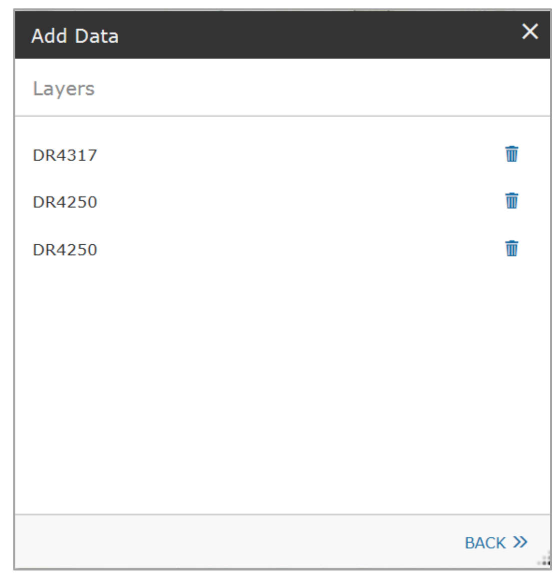


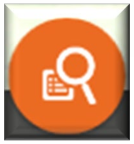


This graphic shows the addition of the DR4250 disaster declaration areas.

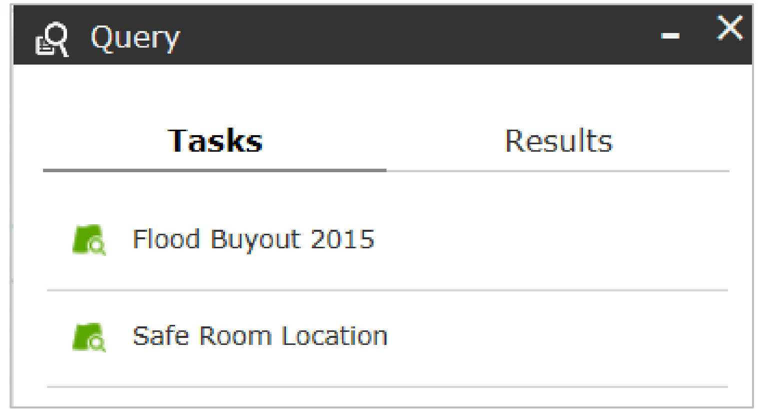


Layers can be removed by clicking the Layers button at the bottom right of the Add Data window. The box will activate the Layers List. Remove layers by clicking on the trashcan icon to the right of the layer. Clicking back at the bottom right will return the user to the previous screen.



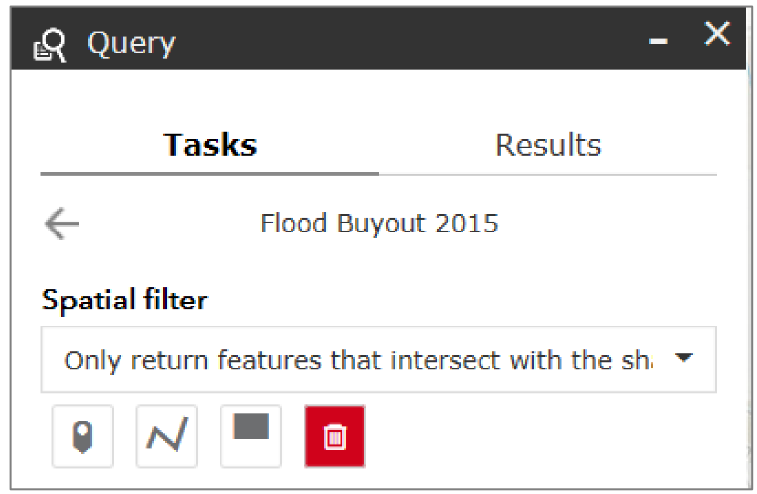


Open the Query Window and it will reveal the layers present in the tool as shown to the right. Click on the Layer wanted for the analysis. In this example, choose Flood Buyout 2015.

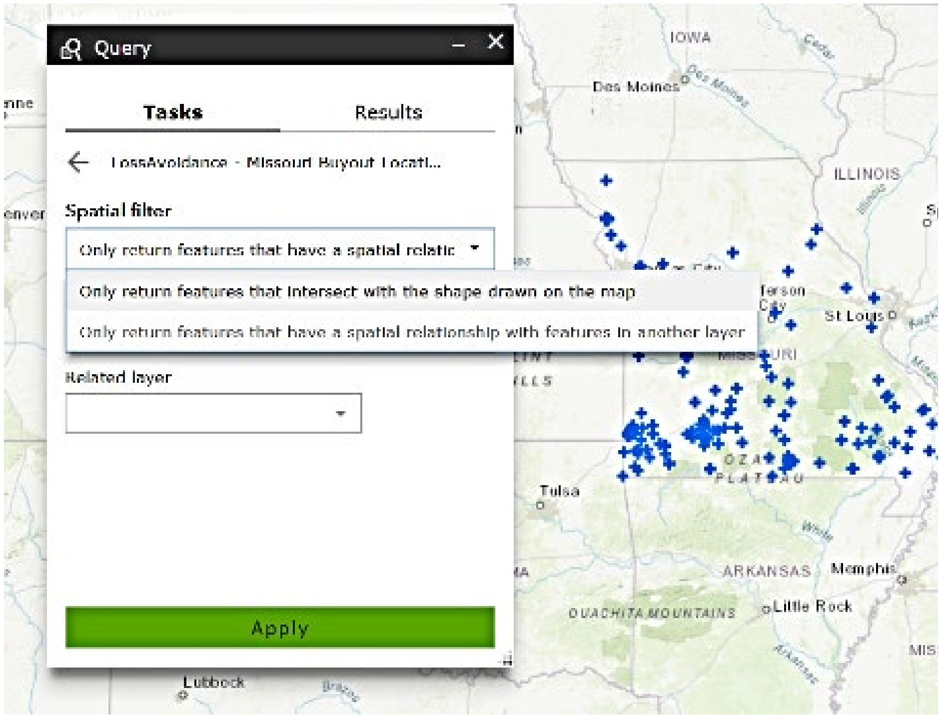


The Spatial filter dropdown menu will give the user the option to query results that have a spatial relationship (intersect or inside) with a shape drawn on the map or with features in another layer.

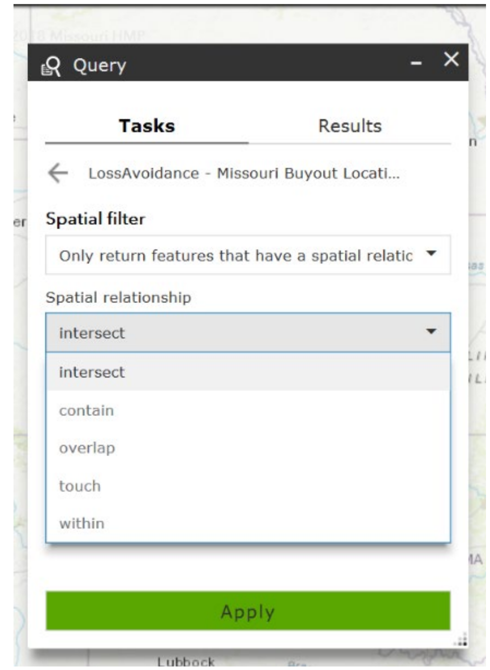
For this example, choose the second (Only return features that have a spatial relationship with features in another layer).

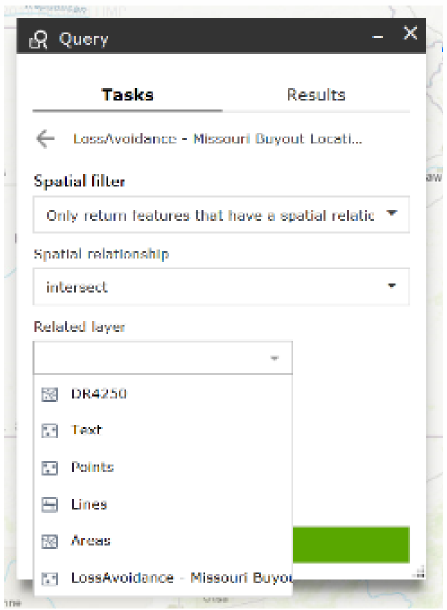


Under Spatial Relationship, the drop-down arrow allows the user to return results that intersect, contain, overlap, touch or are within the area of interest.



For this example, choose "intersect". This will be the most common choice.

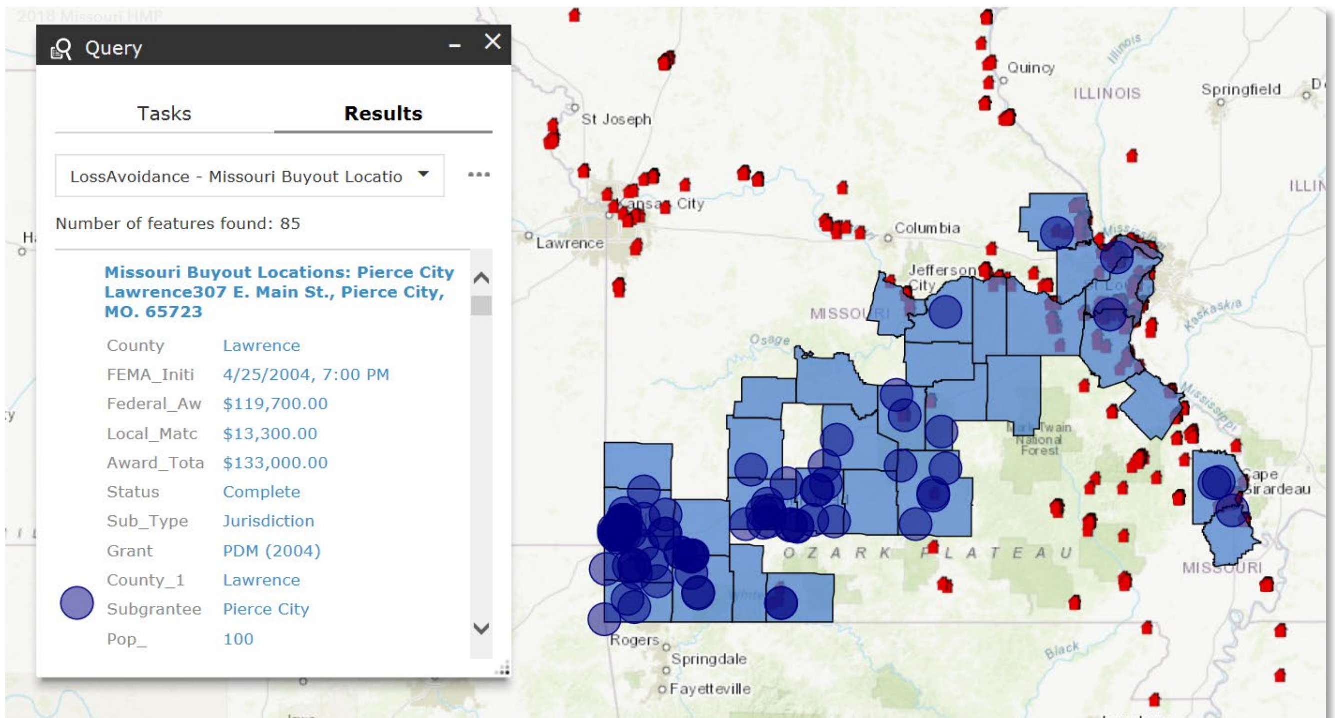


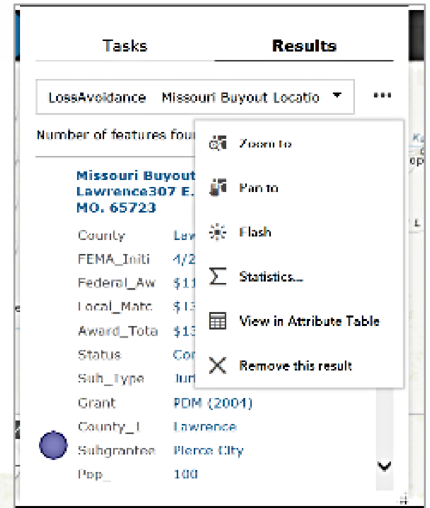


The Related layer drop-down list will allow the user to select which layer to compare against. For this example, DR4250 was chosen.

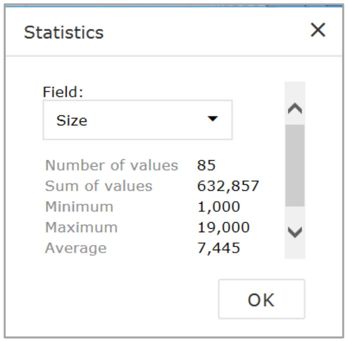
Click the green Apply button at the bottom.

The results will appear on the map as shown below. The results in this example returned 85 buyout locations within the DR4250 declaration zone.





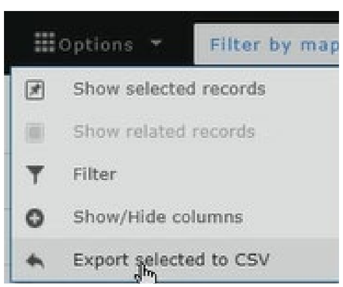
Clicking on the three gray circles to the right of the box that says "Loss Avoidance – Missouri Buyout Location" in the graphic above will provide the user the options to Zoom to extent, Pan to, Flash (the results will flash on the screen), Statistics (run statistics on the results), View in Attribute Table or remove the result from the map.



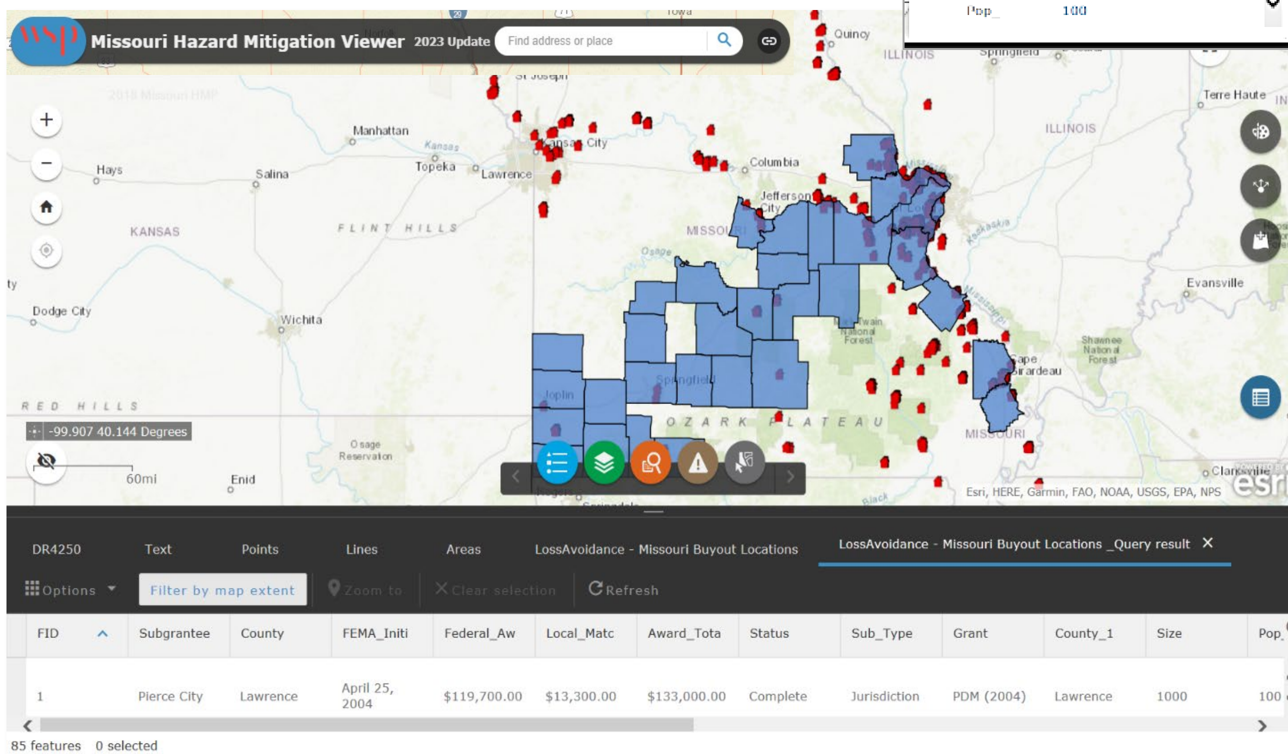
In this example, statistics were calculated for the results returned. Click "OK" to close the box.

For this example, choose the "View in Attribute Table" option. The attribute table will open at the bottom of the screen.

Clicking on the drop-down arrow on the Options tab on the right side of the black attribute header, will reveal options in the graphic to the right. Choose the "Export selected to CSV" option and navigate to a location to save the file. CSV formats files can be opened in either Excel or ArcMap.



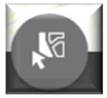
Instructions for this can be found on page 24.

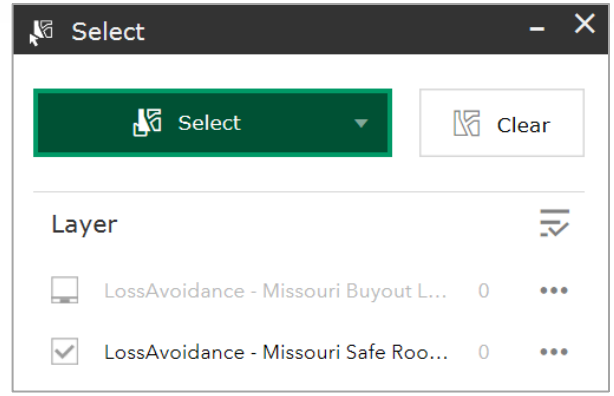


*Note that if the query results in more than 1,000 locations, only 1,000 attributes will be exported. It is recommended to break the query up into smaller parts to remedy this.

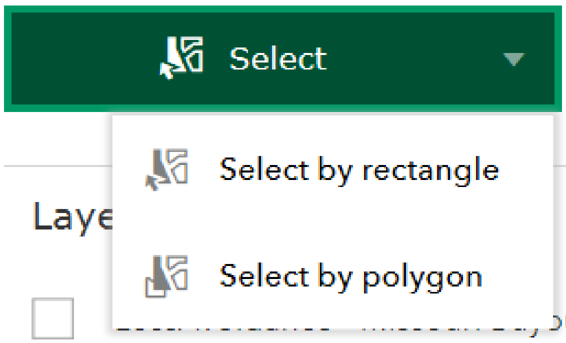
Example #2

In this example, we will mimic the path of a severe thunderstorm with tornadoes in it.

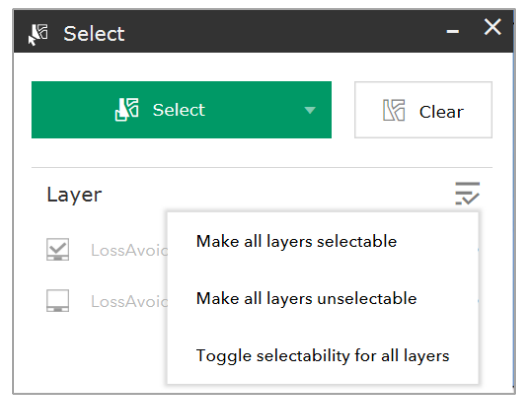
Selection can be done by using the  Select button in the bottom banner which activates the Select window.



Clicking the green Select button will reveal the Select by rectangle option or Select by polygon option.



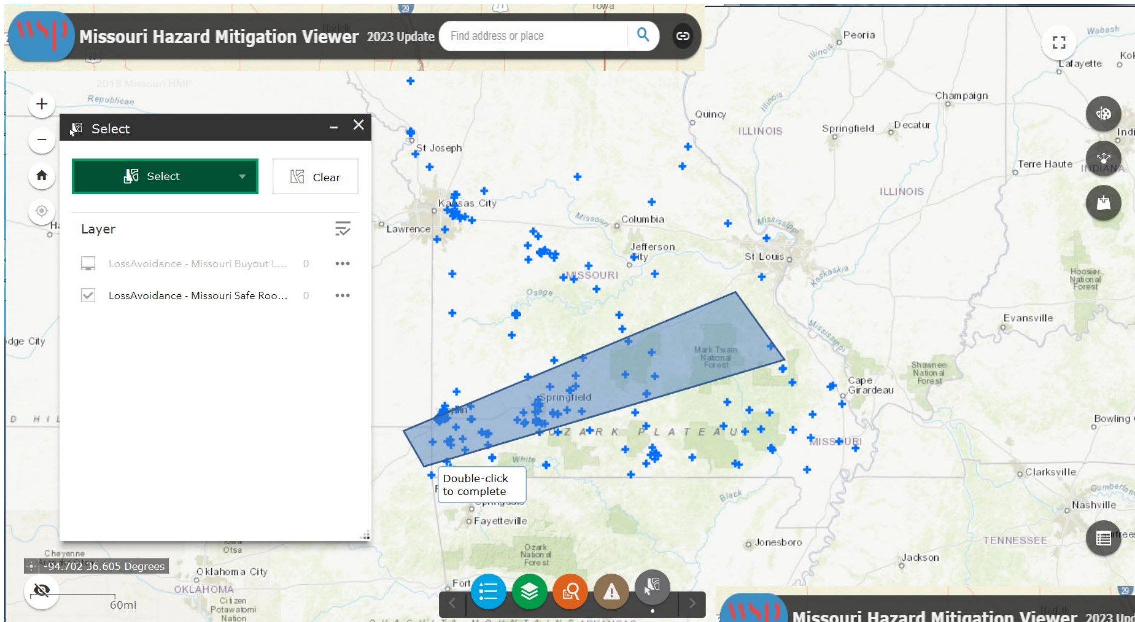
Choose either Select by rectangle or polygon. Ensure that the layer for Saferoom (or Buyout in other scenarios) is active by clicking the checkbox next to the layer name.



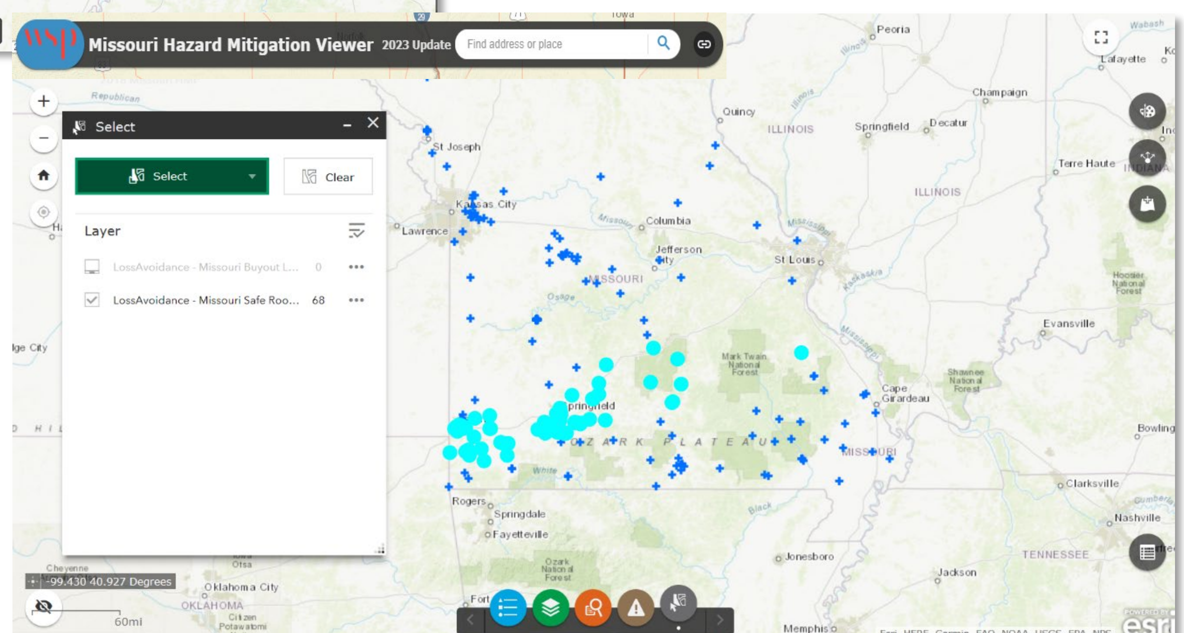
The layers can be made selectable/in-selectable by clicking the checkmark with the three bars icon in the center right and choosing one of the options that appear.

Clicking the Clear button to the right of the green button will clear out the selections.

In this example, the user will mimic the path of the storm by drawing an area of interest using the polygon. Click on the map once to start the polygon, click again to add vertices and double click to complete the polygon.

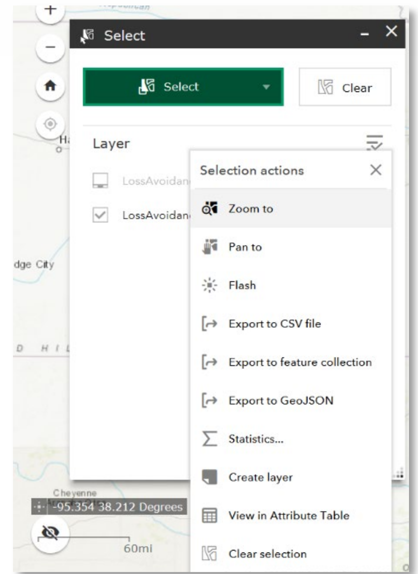


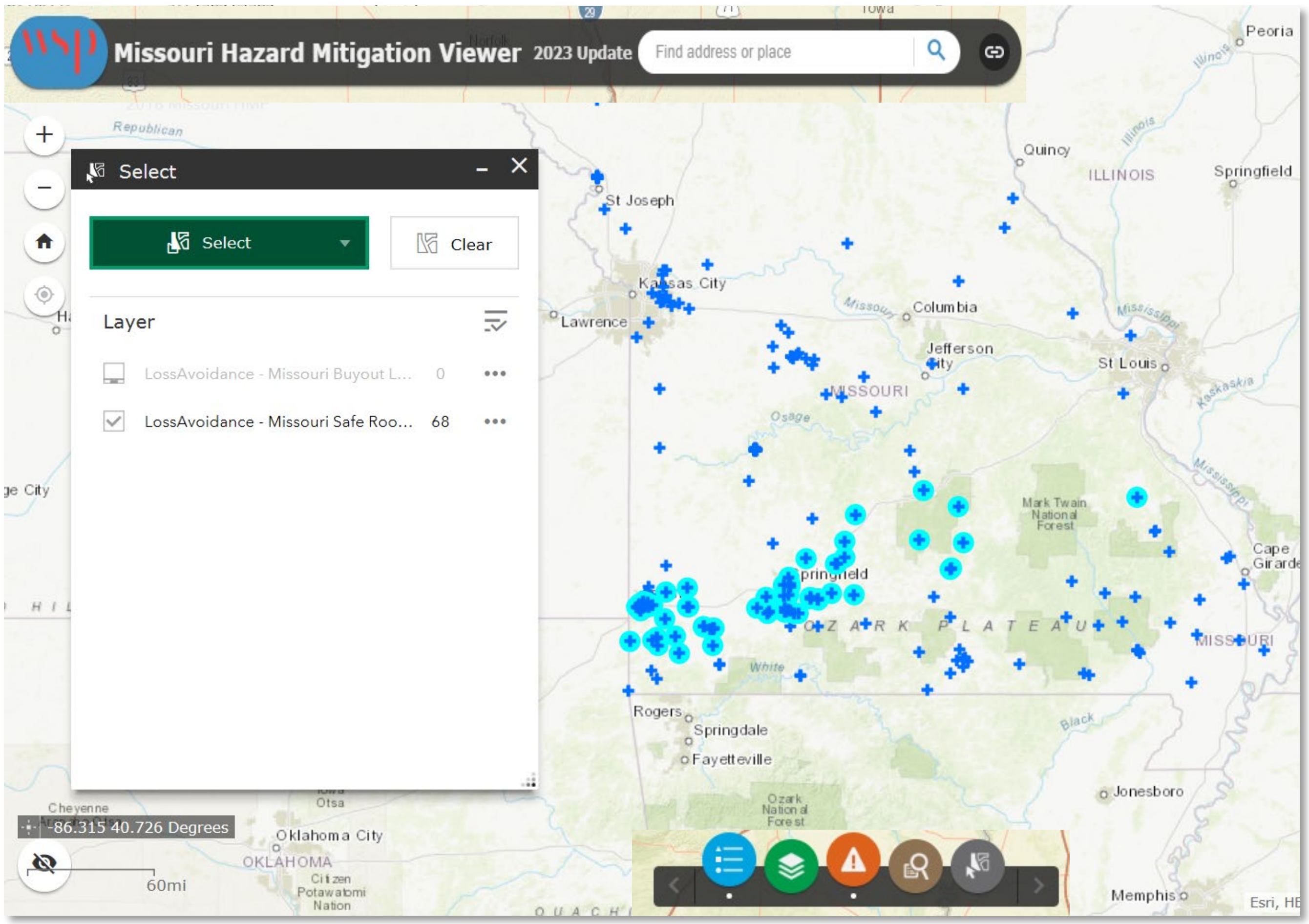
The Saferoom locations inside the polygon drawn will be selected and highlighted on the map.



The selection can be cleared by tapping the clear button to the right of the green Select button. In this example 68 saferooms were returned in the results which is also shown next to the name of the Layer in the Select Window circled in red in the graphic above.

Clicking on the three gray circles to the right of the results number, will reveal a number of options to u for viewing or exporting. In this example, “Create a Layer” was chosen. The user will be prompted to name the layer, Tornado XYZ Damage Area, in this example. This adds the selected Saferooms to the map in a new layer.

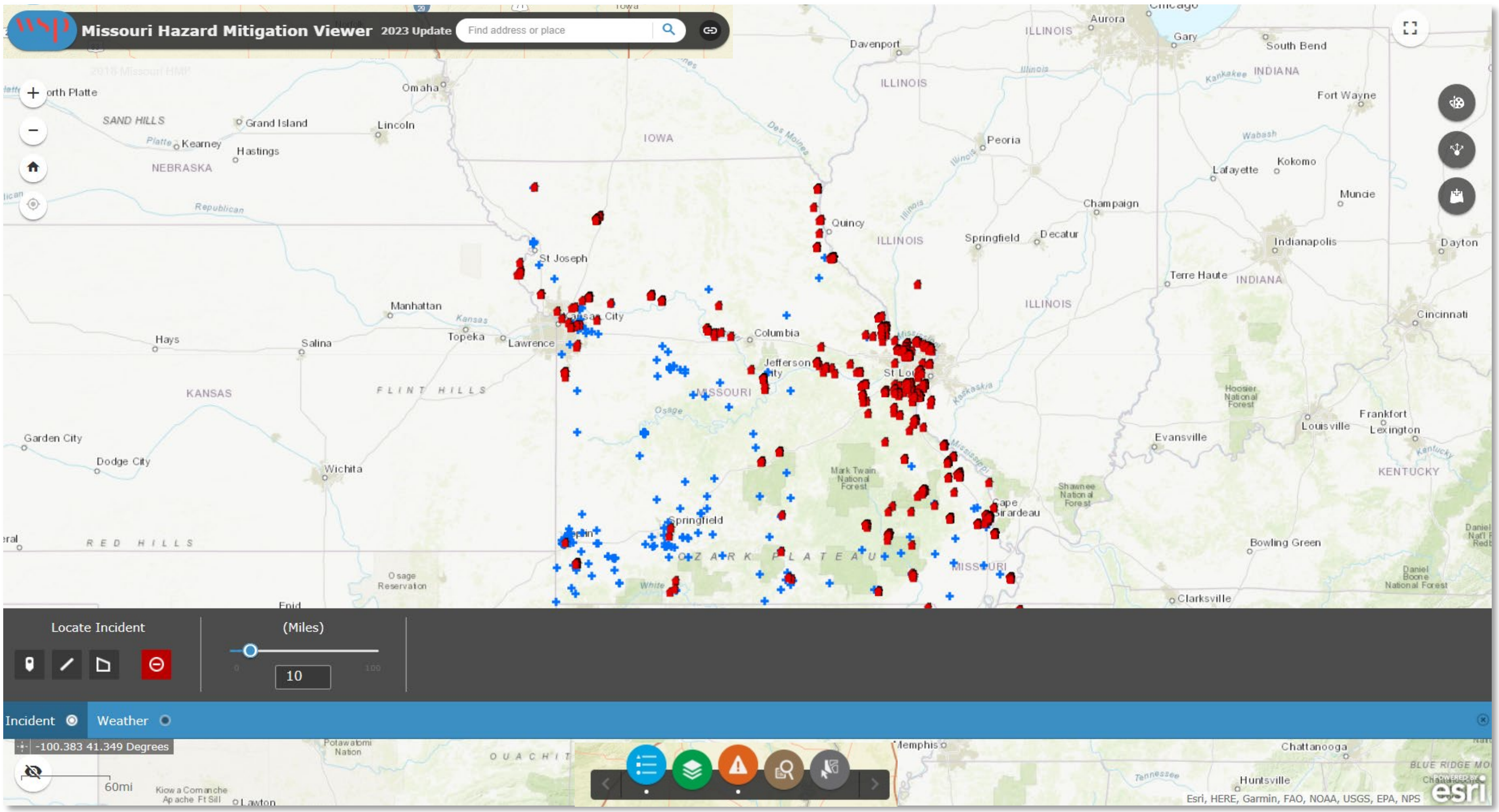


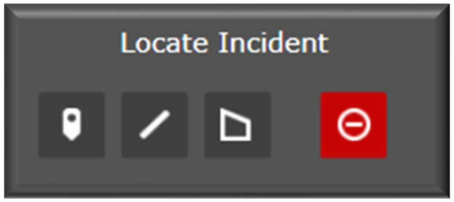


Example #3

Click the orange button on the bottom banner to activate the Locate Incident ribbon. A buffer distance in miles can be set around the incident by moving the slide bar

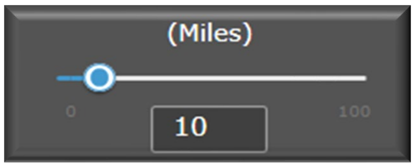
The Locate Incident ribbon can be closed by clicking the small black X at the bottom right of the ribbon.



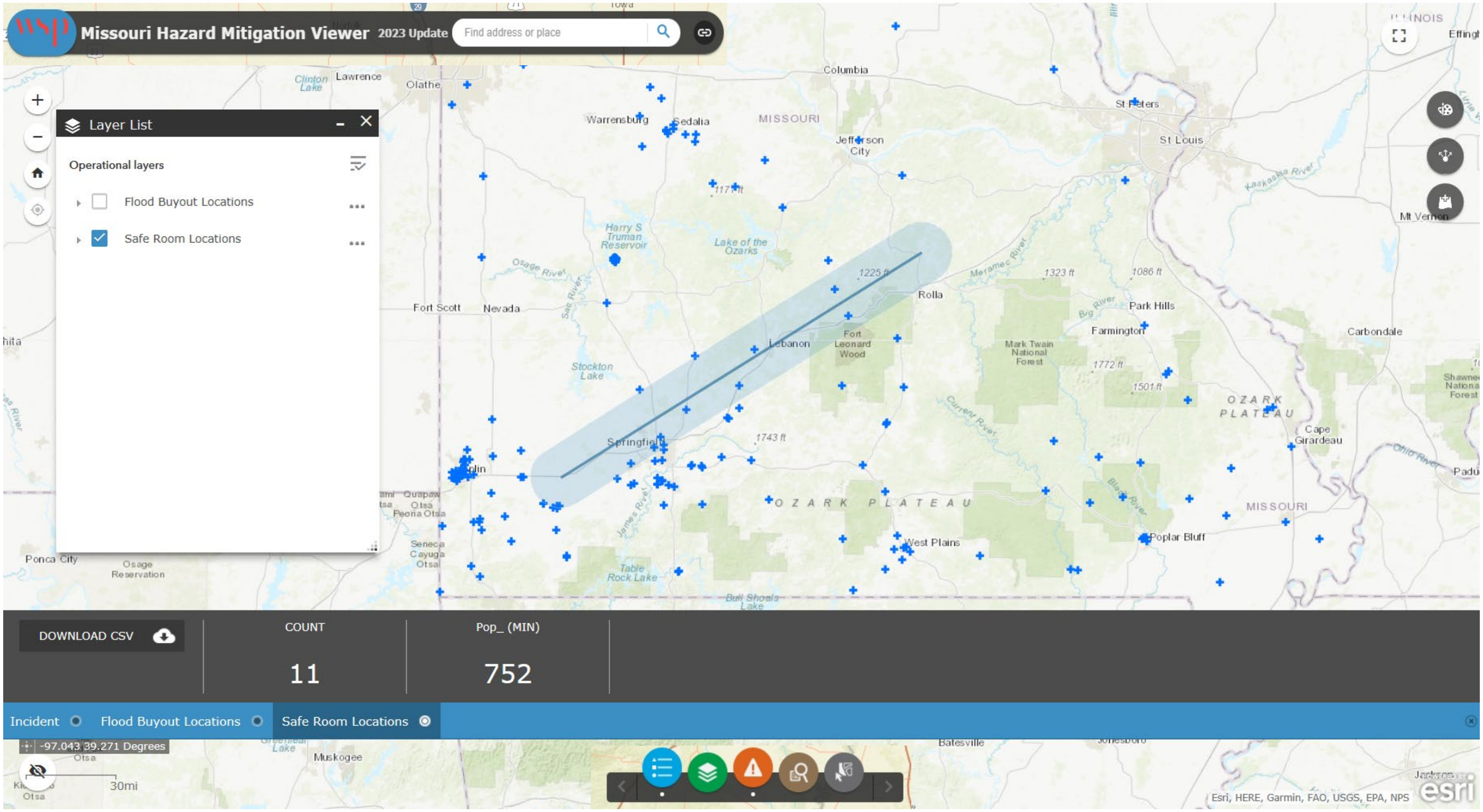


Using either the Locate Incident Buttons on the gray ribbon to simulate and incident.

The  button will all the user to draw a line simulating a storm path as shown in the graphic below.

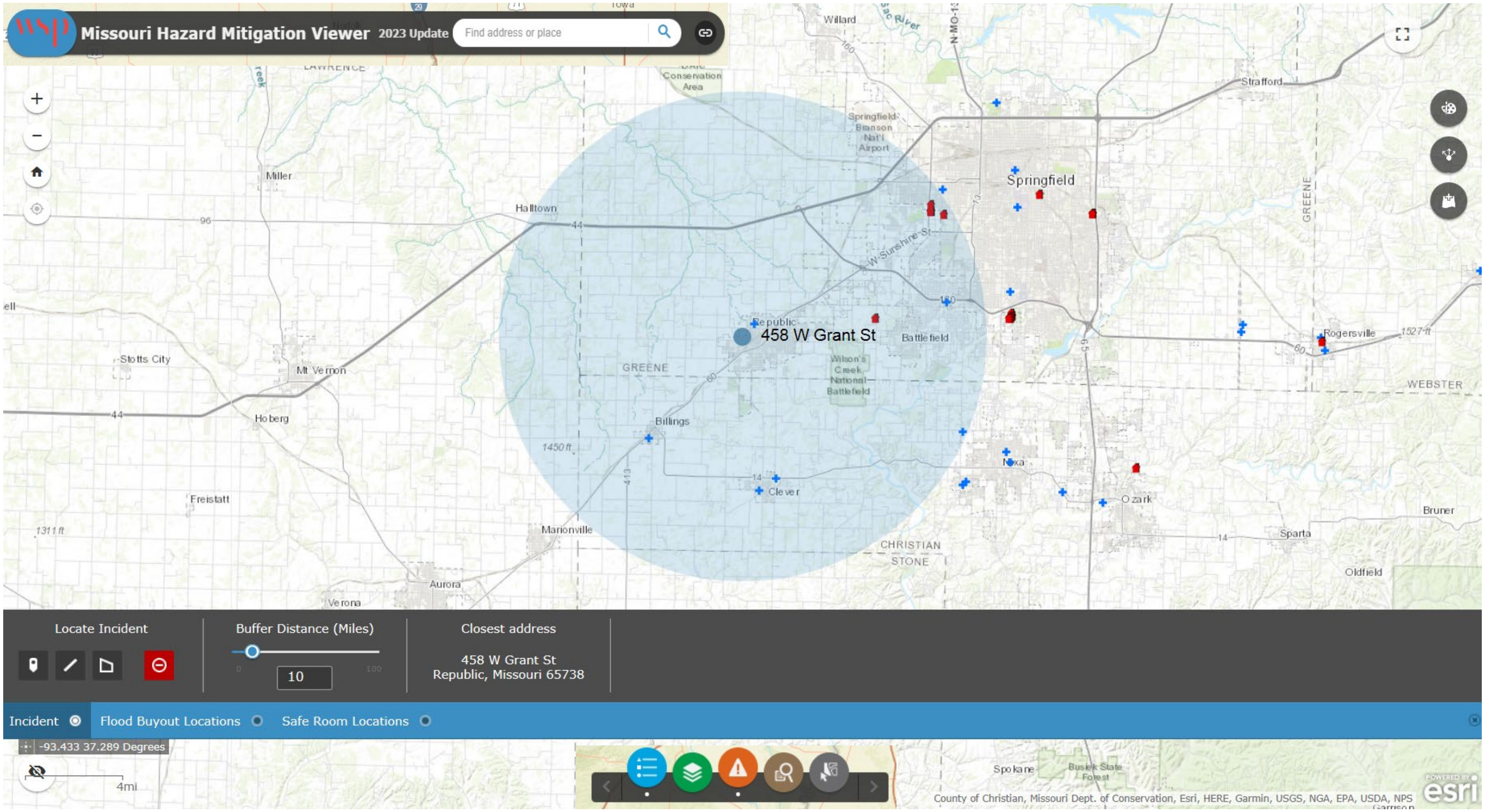
Using the 

slide bar, the area of interest on either side of line can be changed. In the example above, it is set for 10 miles. In the example below it was changed to 25 miles by sliding the blue circle to the right. Alternately, the number 25 can be insert in the number box. The display screen will automatically zoom to the extent of the incident.

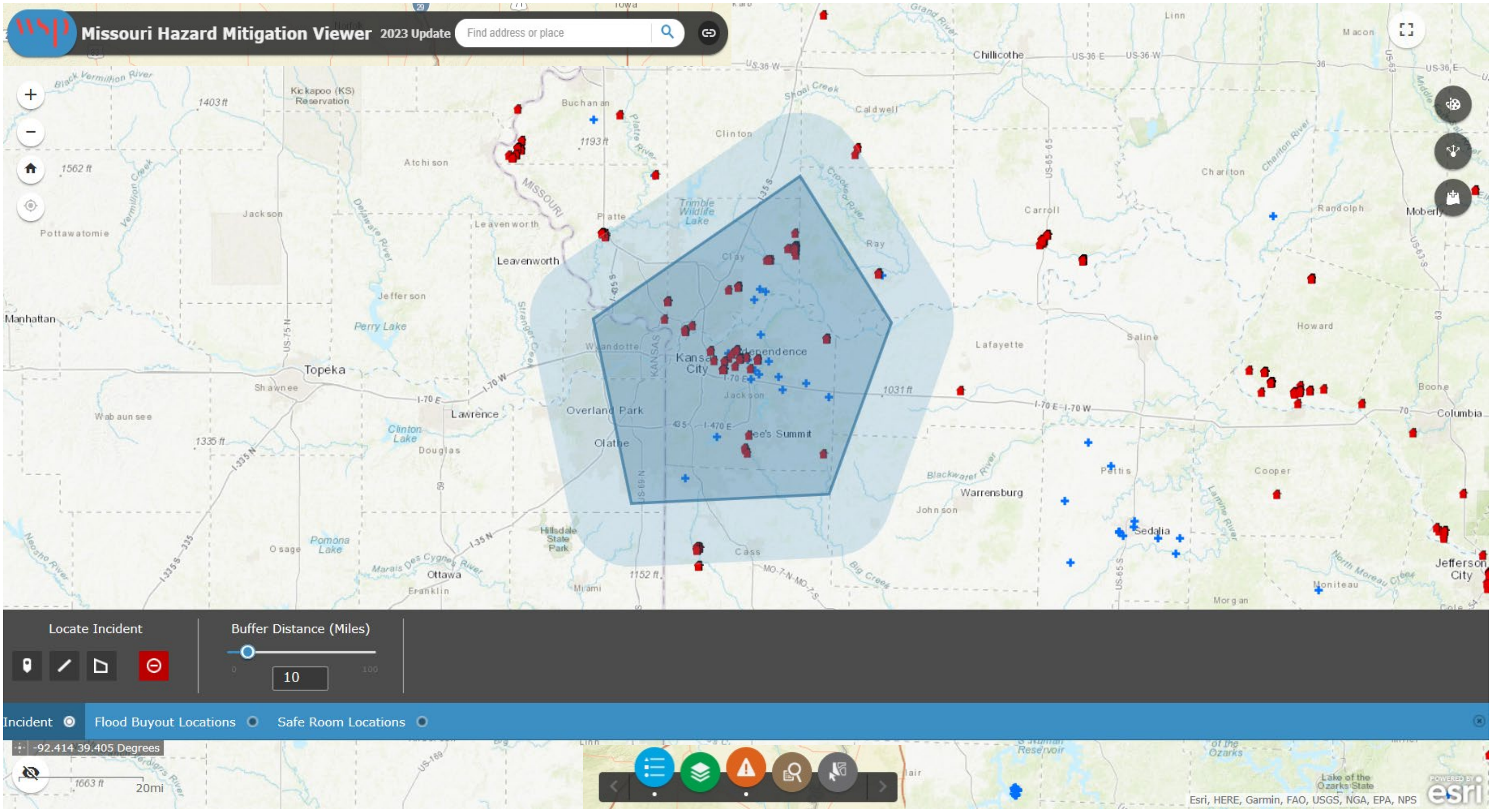


By clicking on the Layer Name in the blue ribbon along the bottom of the page, the count and population attributes for the intersection of the buffered area and the Operational Layer will be summarized in the gray ribbon. The CSV file of the selected locations can be downloaded using the Download CSV file on the gray ribbon.

The  will allow the user to drop a point on the map with the buffer applied as shown below.



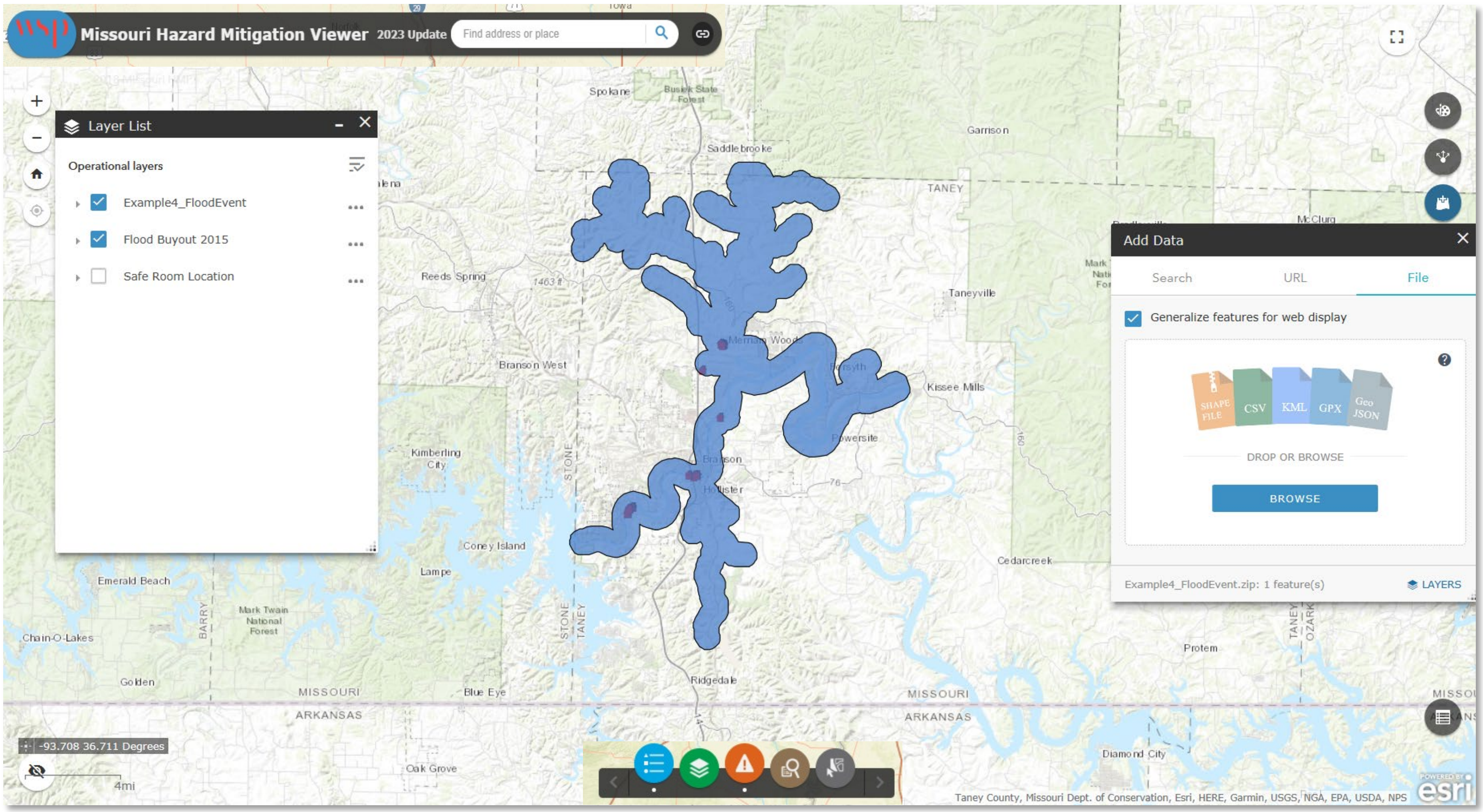
The  will allow the user to create a polygon on the map as shown below.



The  allows the user clear or remove the incident on the map.

Example #4

Another example of using the LAAT to generate Loss Avoidance estimates can be created using a polygon of flooding along a specific source as shown in the graphic below. Add the polygon of a specific flood event using the Add Data button. Then Query and Export as shown in Example 1.



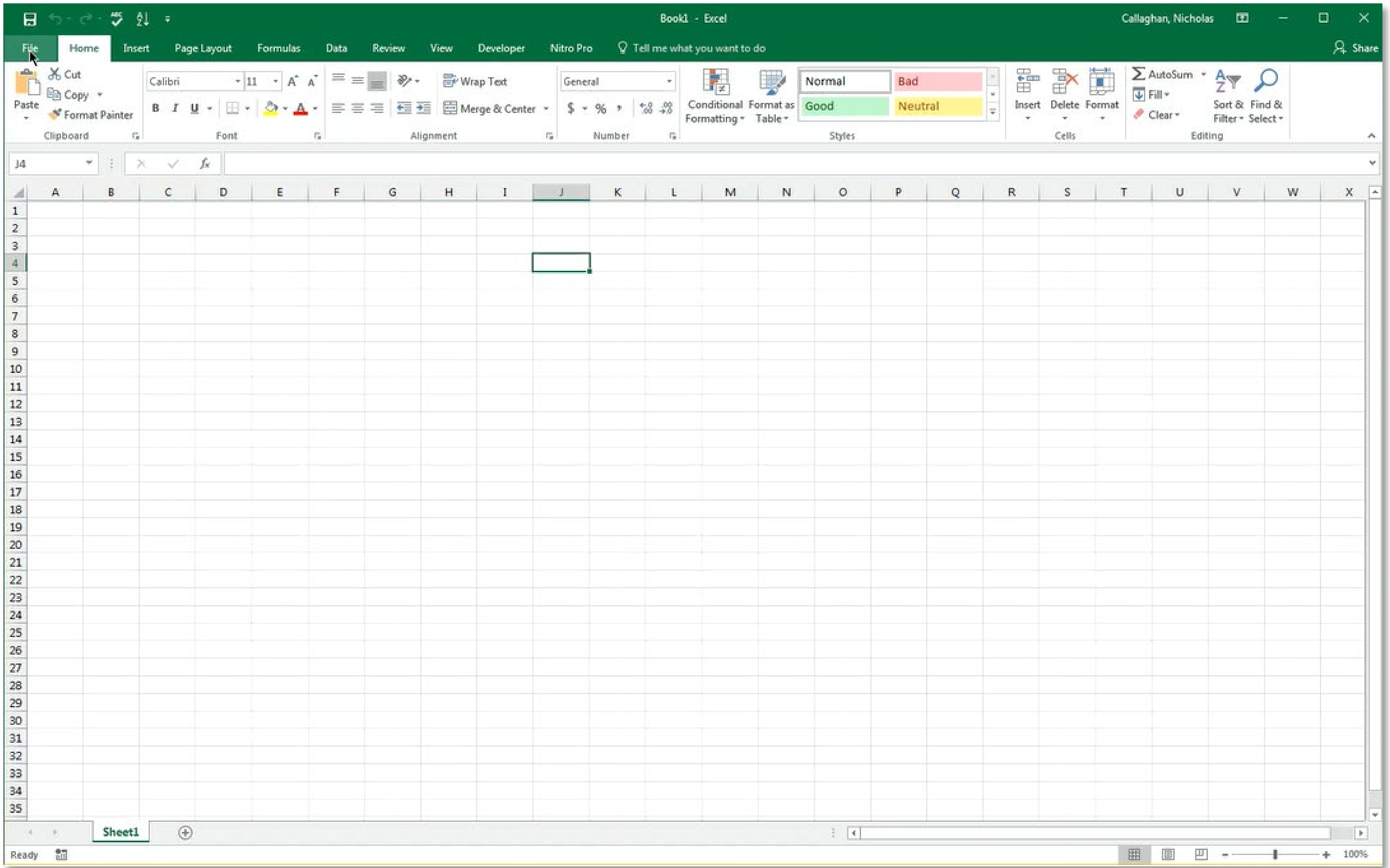
The table shown below is Table 7.11 from the Hazard Mitigation Plan and was generated from the LAAT exports utilizing the combined methods described in Examples 1 and 4 of this guide.

Community	Total # of Acquired Structures	Total # of Acquired Structures Located within the SFHA	Total Project Investment	Avoided Loss DR 4250		Avoided Loss DR 4317		Total Avoided Loss	Loss Ratio DR 4250	Loss Ratio DR 4317	Total Loss Ratio
				Structure Damage	Contents Damage	Structure Damage	Contents Damage				
Franklin	156	101	$4,103,010	$4,321,697	$2,160,849	$4,321,697	$2,160,849	$12,965,091	1.58	1.58	**3.16**
Gasconade	6	2	$556,074	$48,354	$24,177	$48,354	$24,177	$145,062	0.13	0.13	**0.26**
Greene	18	9	$1,128,880	$431,477	$215,739	$431,477	$215,739	$1,294,431	0.57	0.57	**1.15**
Jasper	3	2	$126,341	$84,228	$42,114	$84,228	$42,114	$252,684	1	1	**2**
Jefferson	517	147	$9,338,333	$3,080,801	$1,540,401	$3,080,801	$1,540,401	$9,242,403	0.49	0.49	**0.99**
Montgomery	77	4	$328,281	$96,708	$48,354	$96,708	$48,354	$290,124	0.44	0.44	**0.88**
Newton	68	53	$1,791,146	$1,375,476	$687,738	$1,375,476	$687,738	$4,126,428	1.15	1.15	**2.3**
Pulaski	19	8	$505,225	$212,728	$106,364	$212,728	$106,364	$638,184	0.63	0.63	**1.26**
St. Charles	1456	570	$15,459,051	$12,614,507	$6,307,254	$10,352	$5,176	$18,937,289	1.22	0	**1.22**
St. Louis	676	402.5	$19,598,189	$16,348,990	$8,174,495	$16,322,430	$8,161,215	$49,007,130	1.25	1.25	**2.5**
Ste. Genevieve	81	33	$1,038,091	$390,012	$195,006	$390,012	$195,006	$1,170,036	0.56	0.56	**1.13**
Taney	23	21	$3,379,541	$3,376,649	$1,688,325	$3,325,269	$1,662,635	$10,052,877	1.5	1.48	**2.97**
Grand Total	**3100**	**1353**	**$74,073,874**	**$42,381,627**	**$21,190,814**	**$29,699,532**	**$14,849,766**	**$108,121,739**	**0.86**	**0.6**	**1.46**

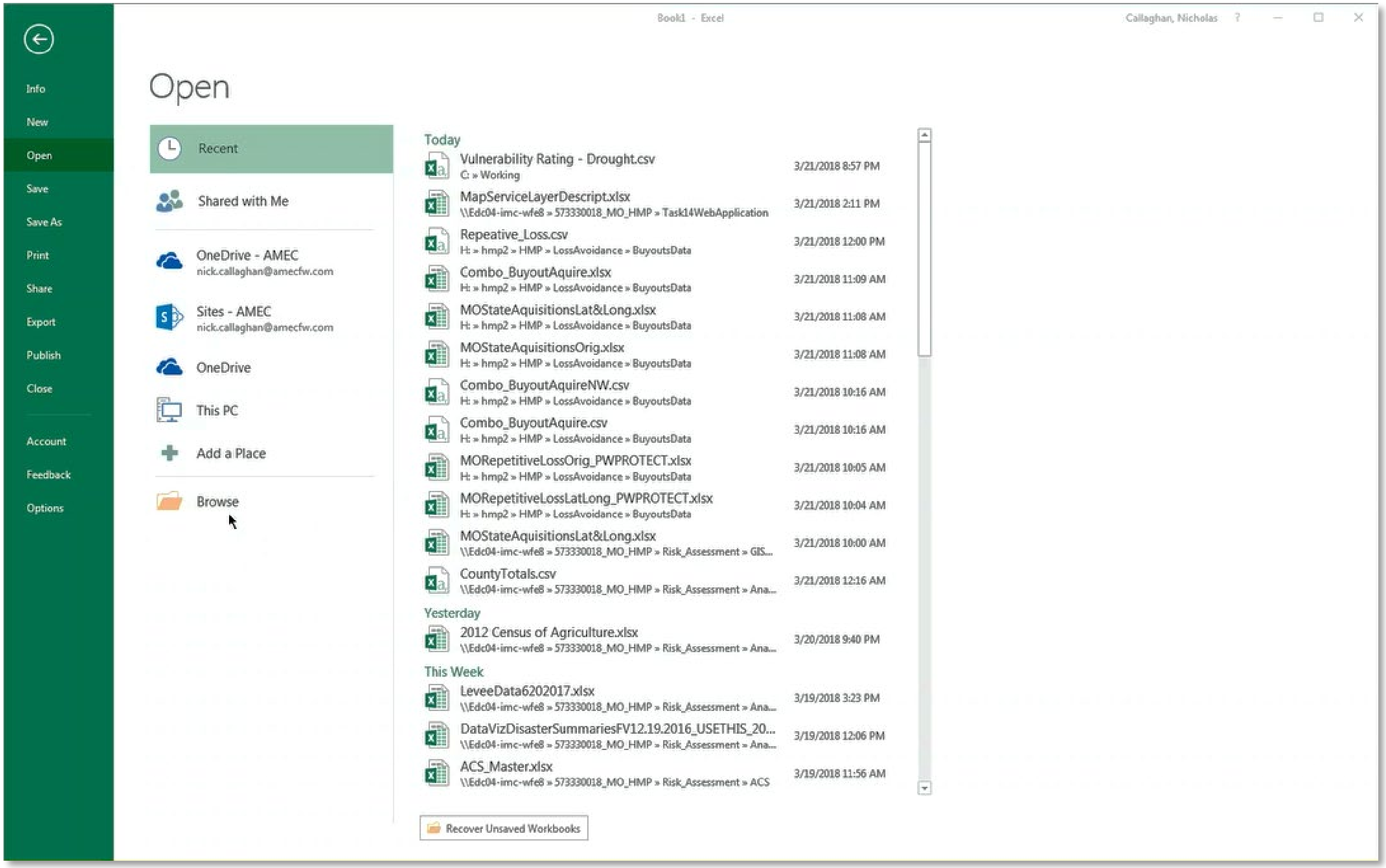
Using CSV files

To open in Excel:

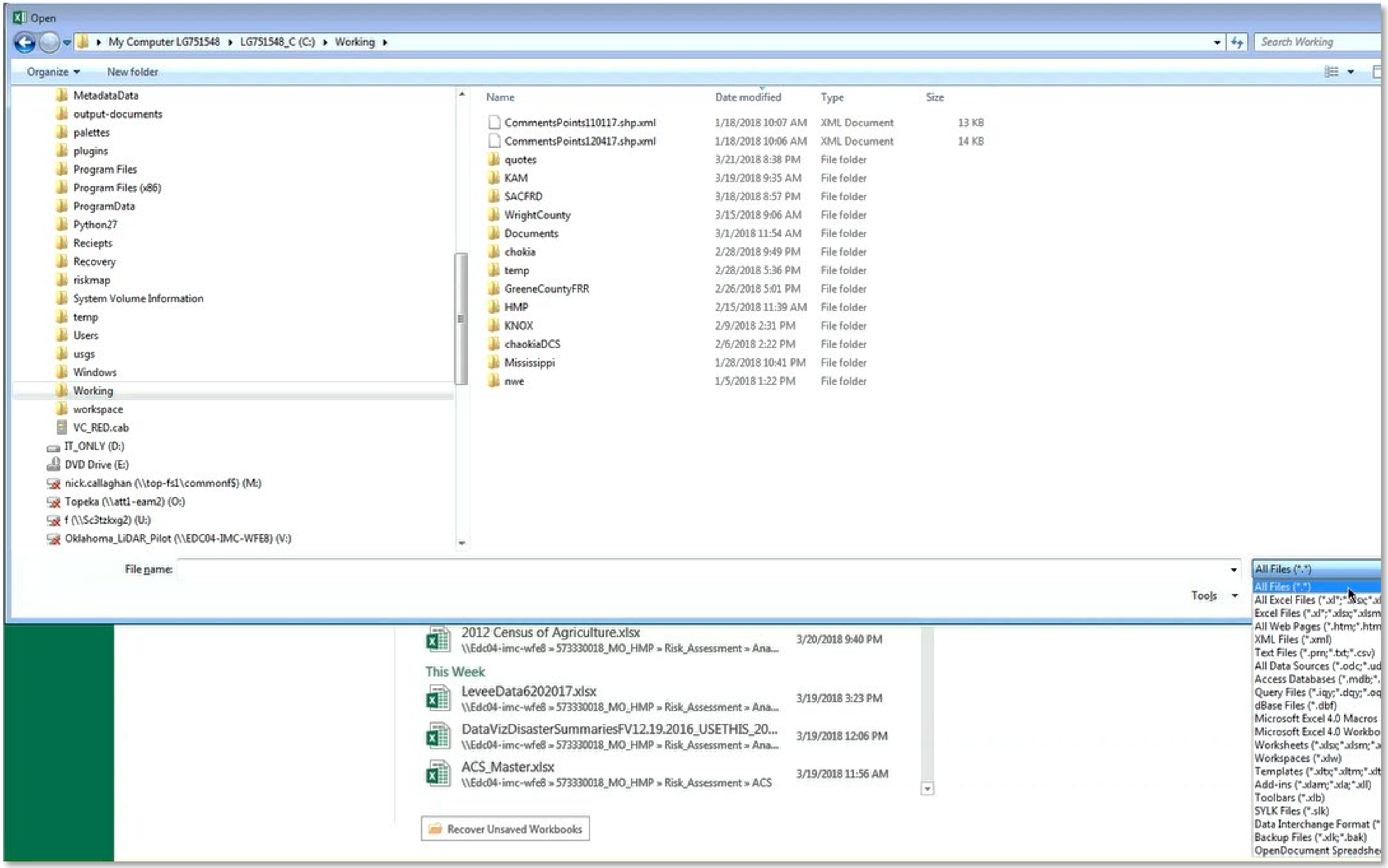
1) Open a blank Excel file.



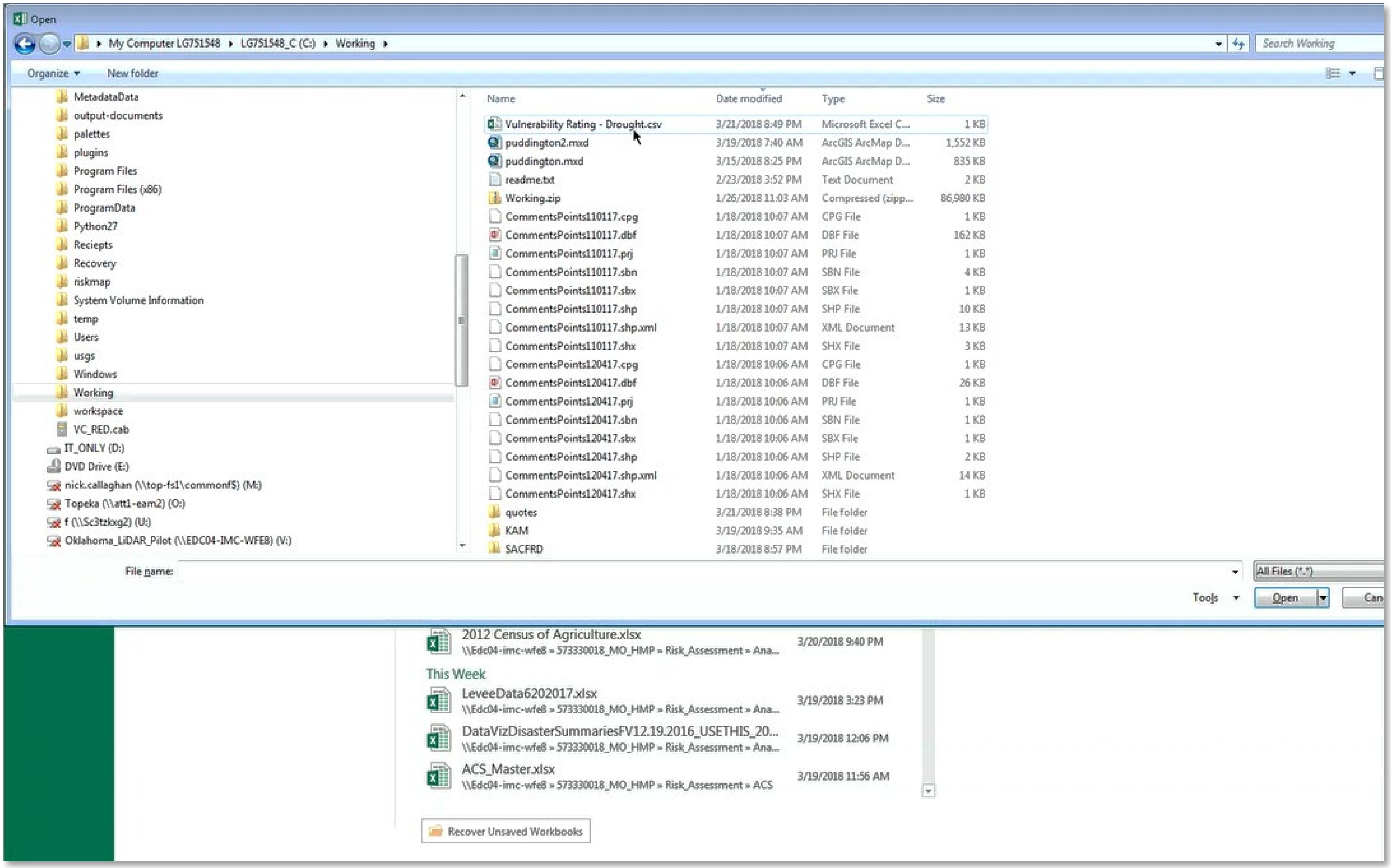
2) Click File and Browse to the CSV file



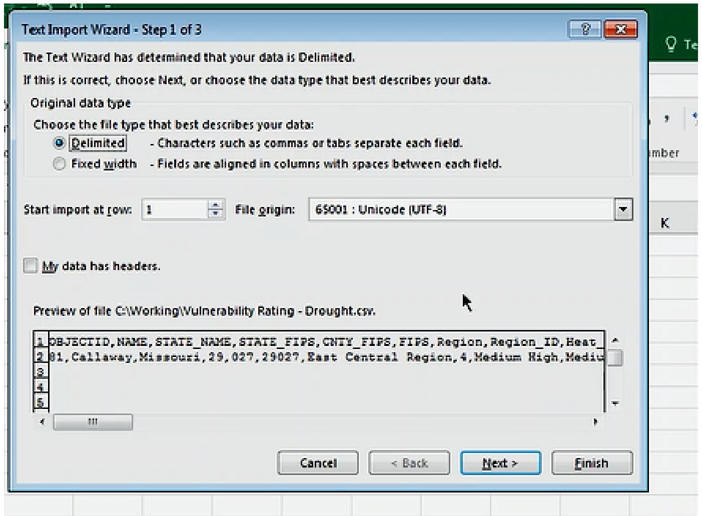
3) Navigate to the saved CSV location. Using the dropdown arrow for file types in the bottom right side of the window, choose "All Files (*.*).



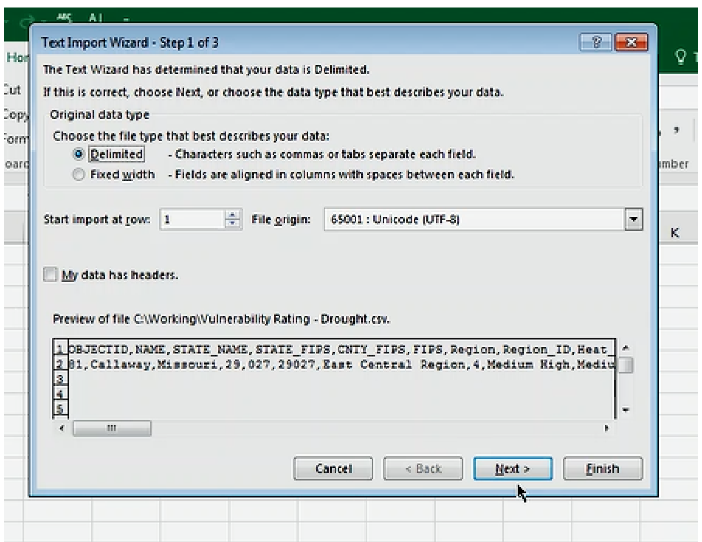
4) Click on the CSV file in the File Name window.



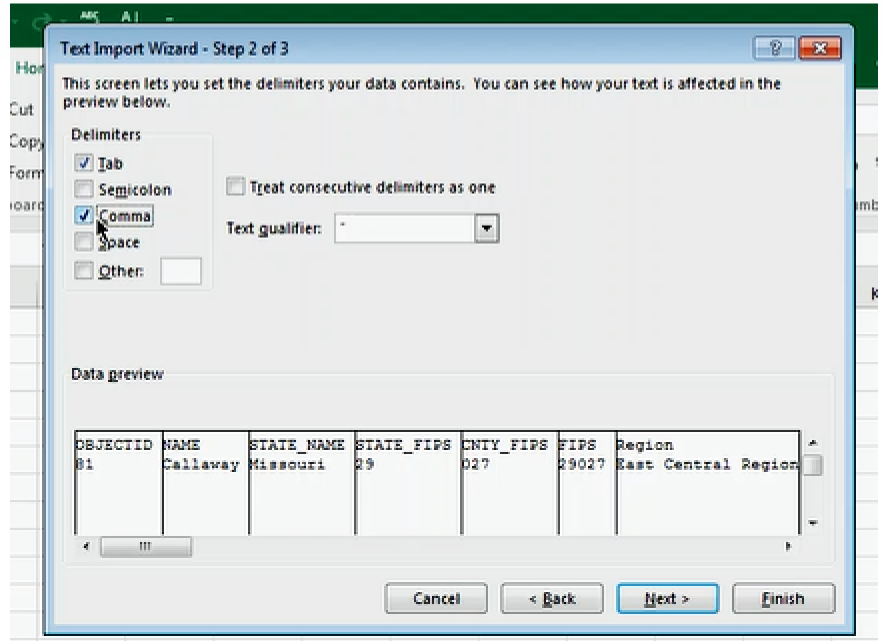
5) A Text Import Wizard window will open showing Step 1 of 3. Choose the “Delimited” radio button in the upper middle of the window.



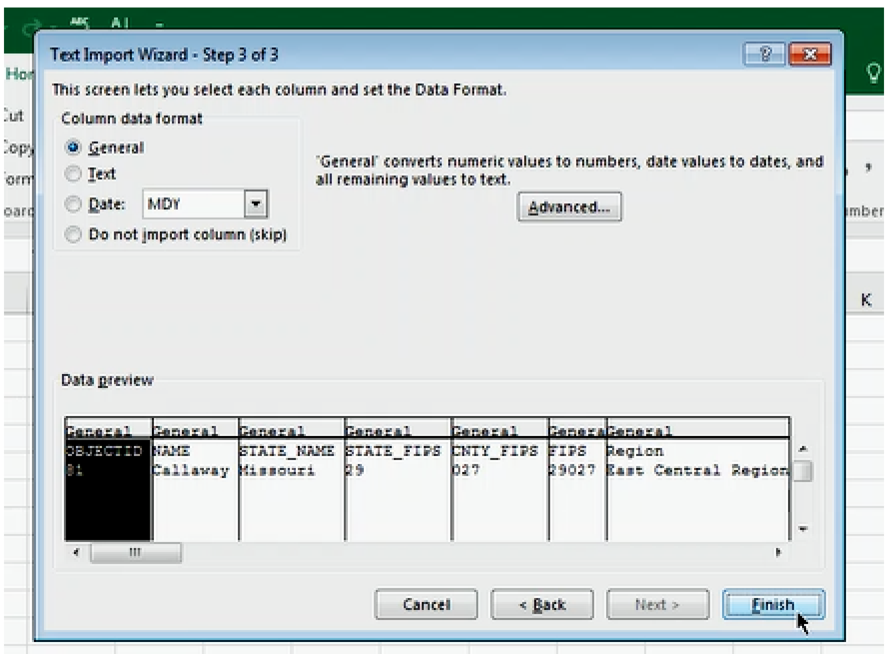
6) Then Click “Next” at the bottom right.



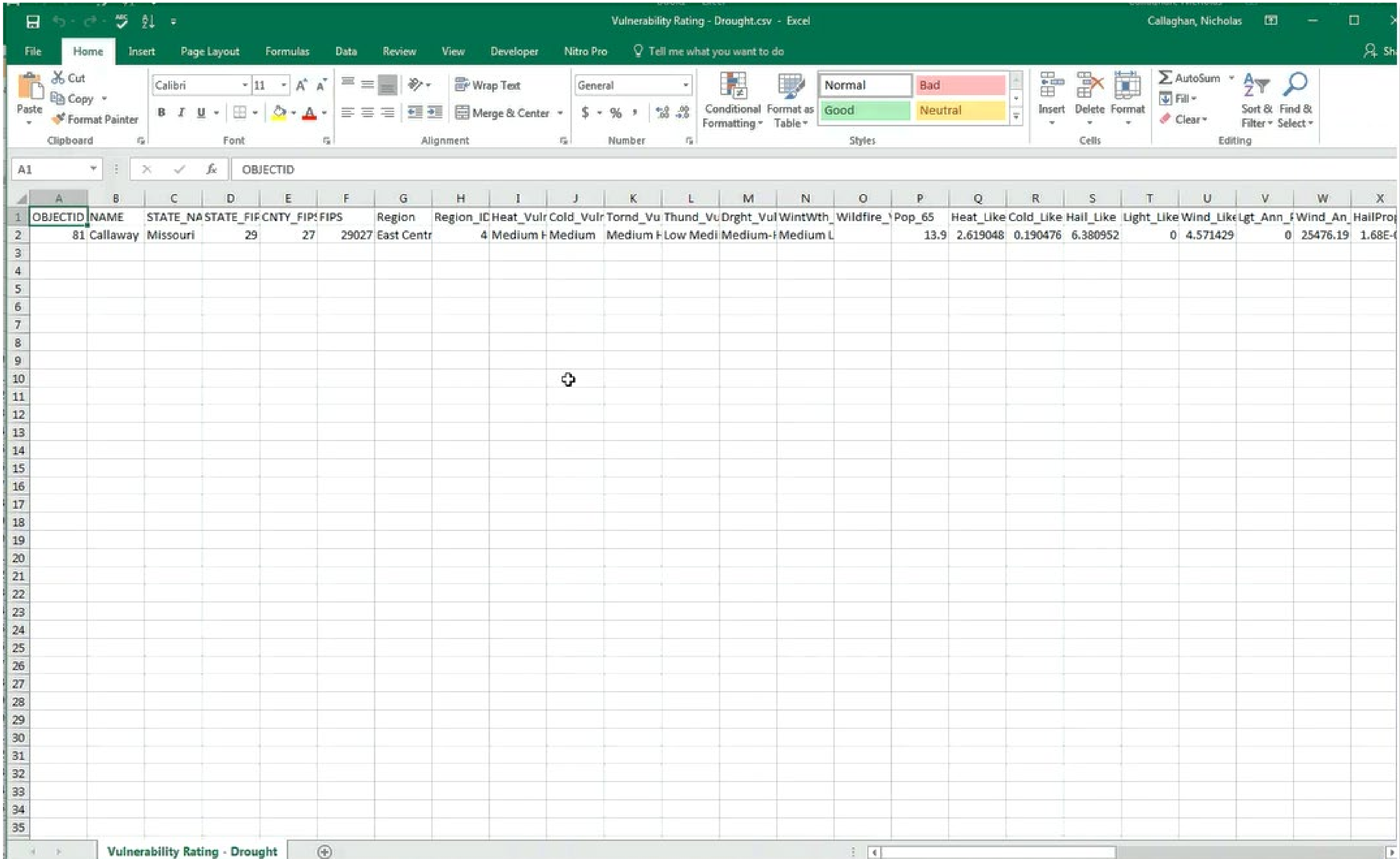
7) The Step 2 of 3 Text Import Wizard Window will open. Select the "Tab" and "Comma" check boxes on the left. Then Click "Next" at the bottom.



8) The Step 3 of 3 Text Import Wizard window will open. Click the "General" radio button on the left. Then click "Finish" at the bottom.

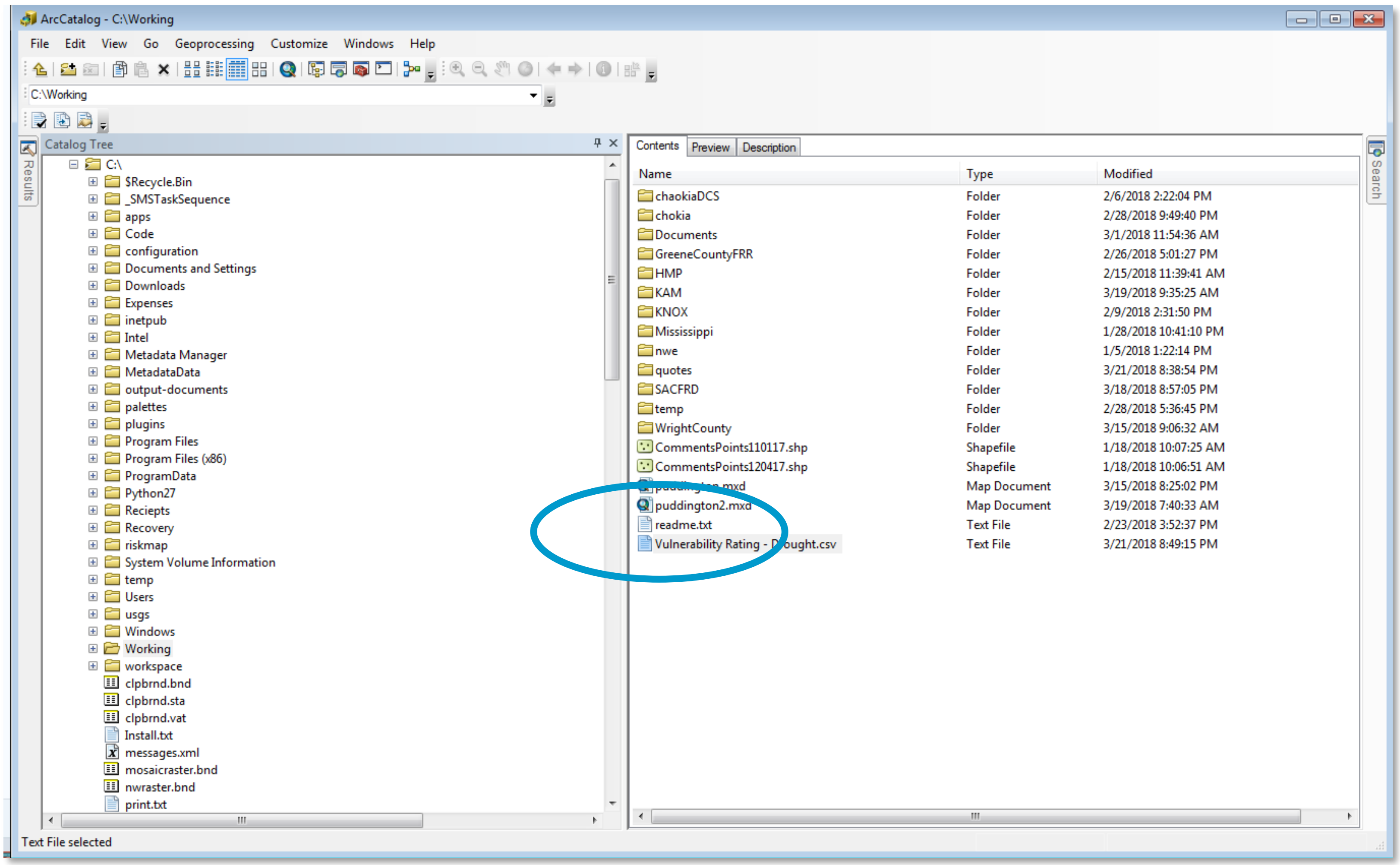


9) The Text Import Wizard window will shut and the data will appear in the Excel spreadsheet.

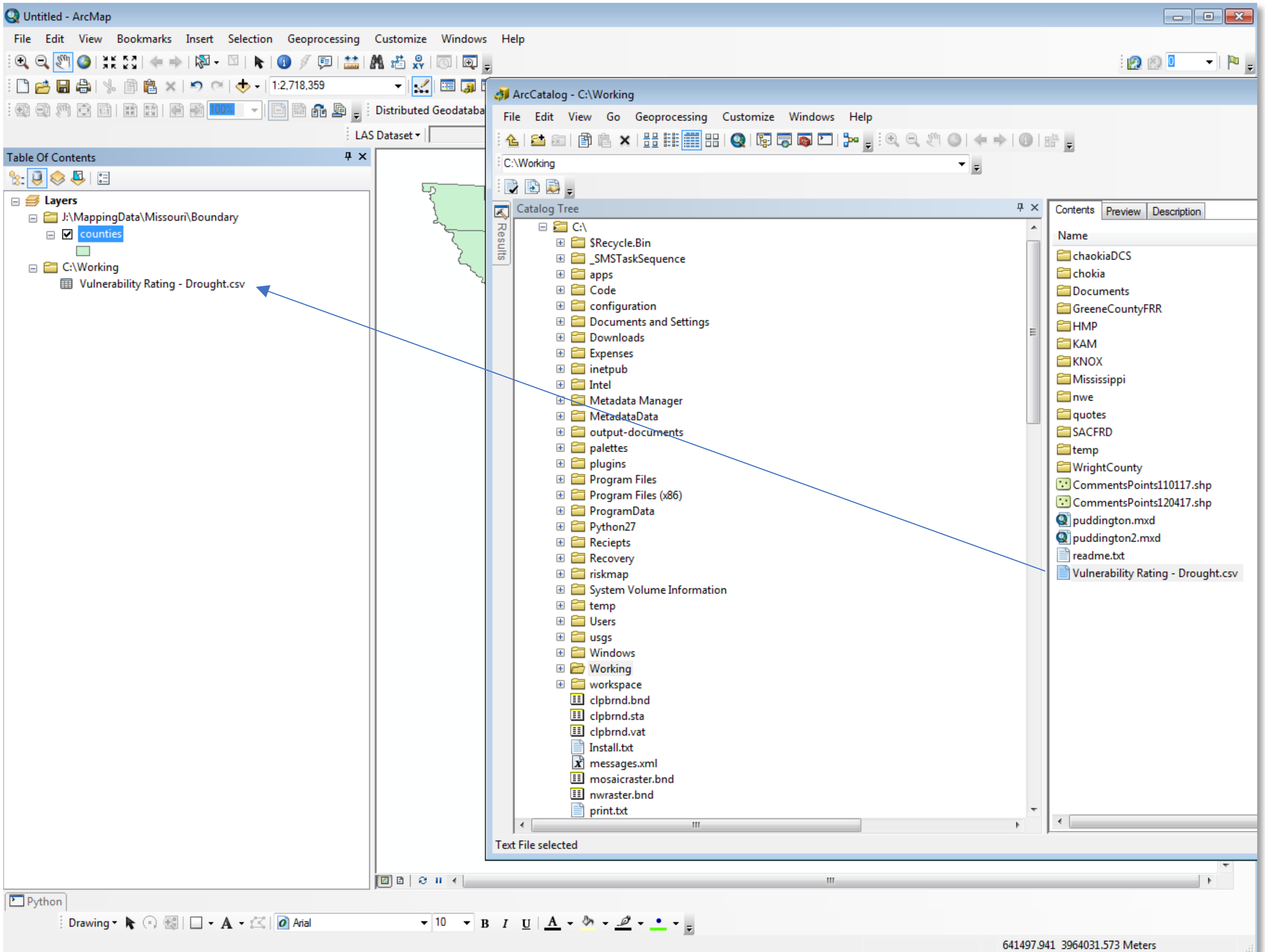


To Open the CSV file in ArcGIS:

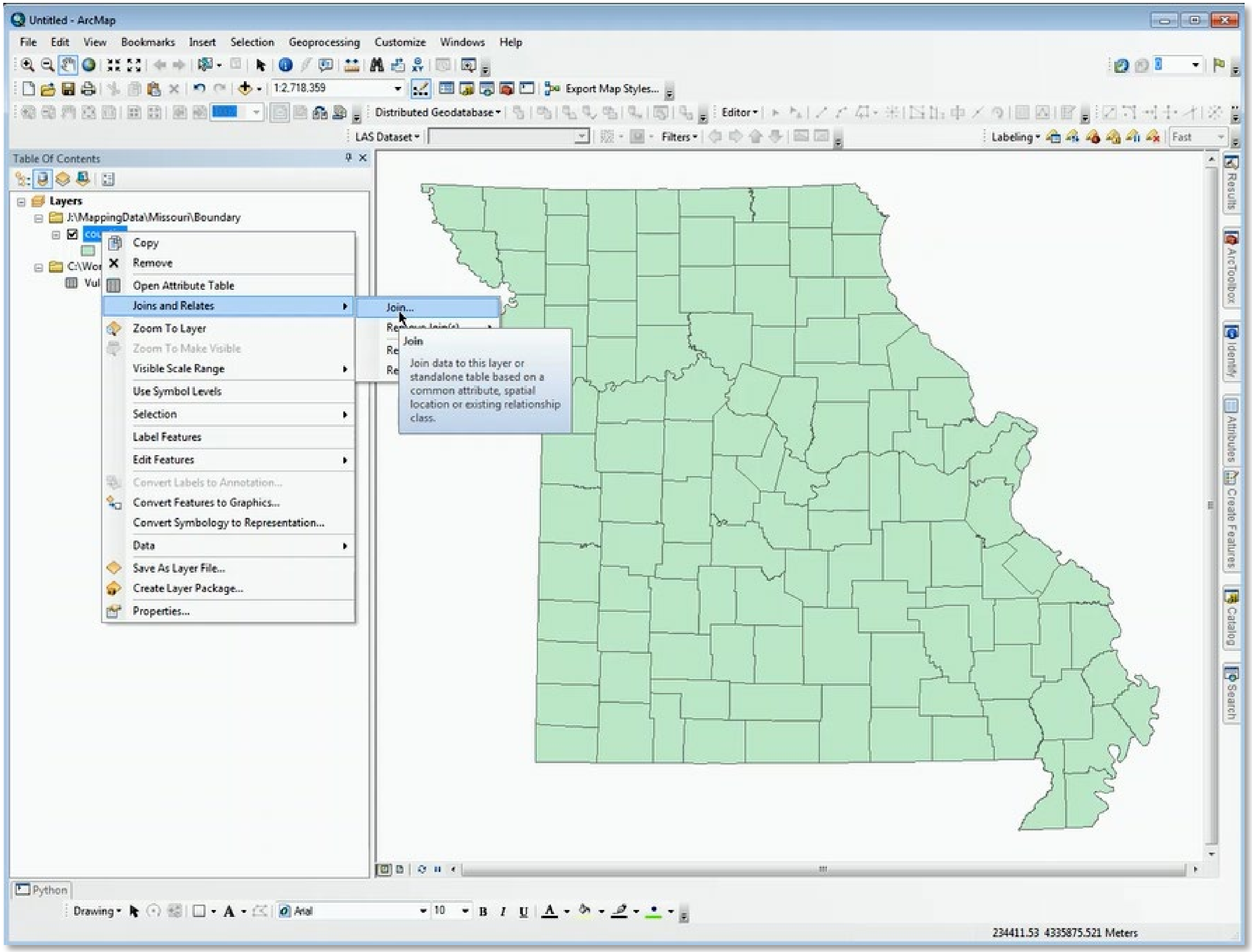
1) Open ArcMAP and then ArcCatalog. Navigate to the stored CSV file location in ArcCatalog.



2) Drag the CSV file from Catalog into ArcMAP. Also add to the ArcMap a county boundary shapefile.



3) Join the CSV file to the County shapefile by right clicking on the County shapefile in the Table of Contents window to open the options window, choosing **"Joins and Relates "**and then **"Join".**



4) A Join Data window will open. Choose the following options utilizing the drop-down arrows:

a) Join attributes from a table

b) Choose the field of the County

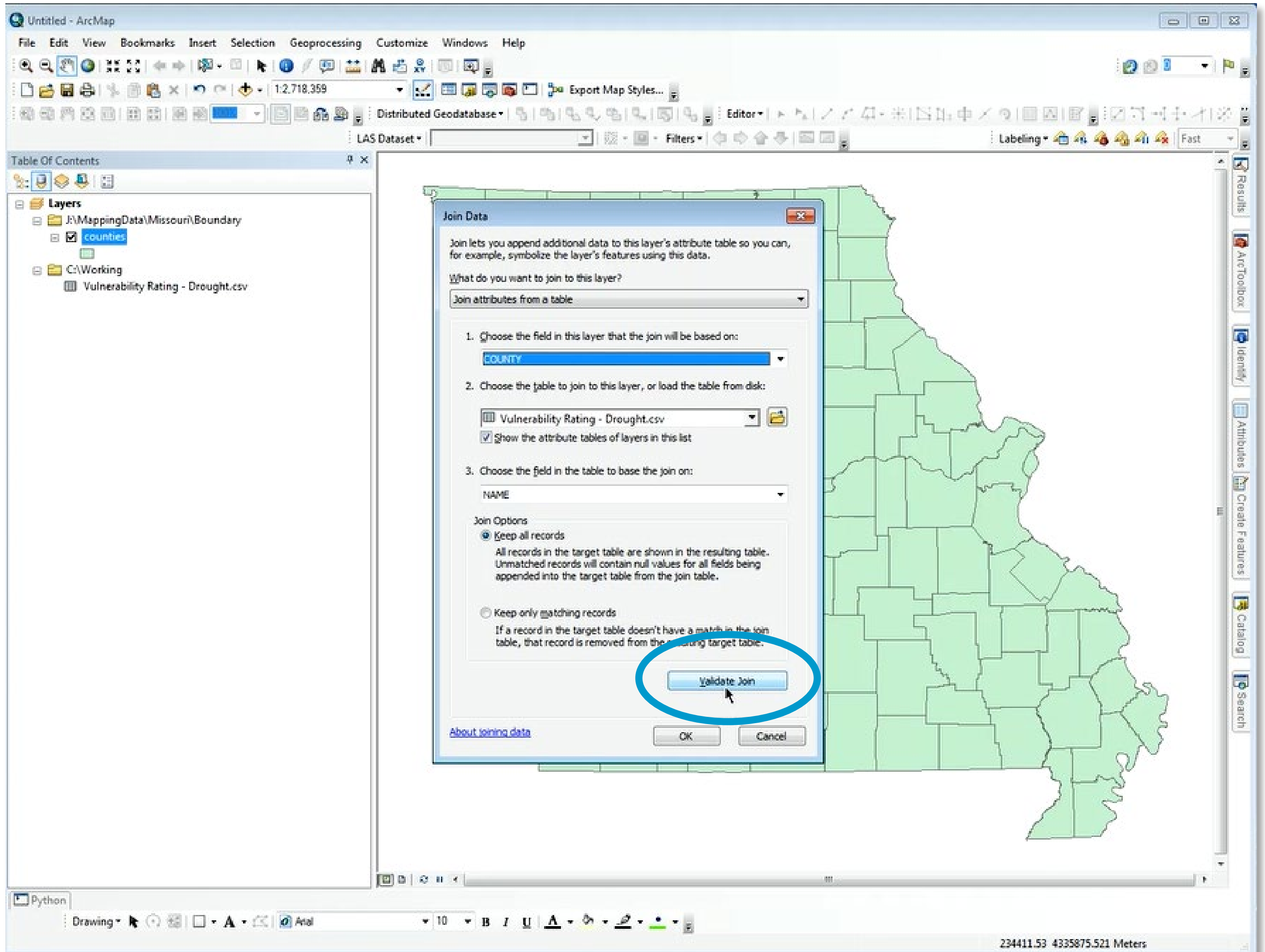
c) Choose the CSV file name

d) Choose the field with the County name in it

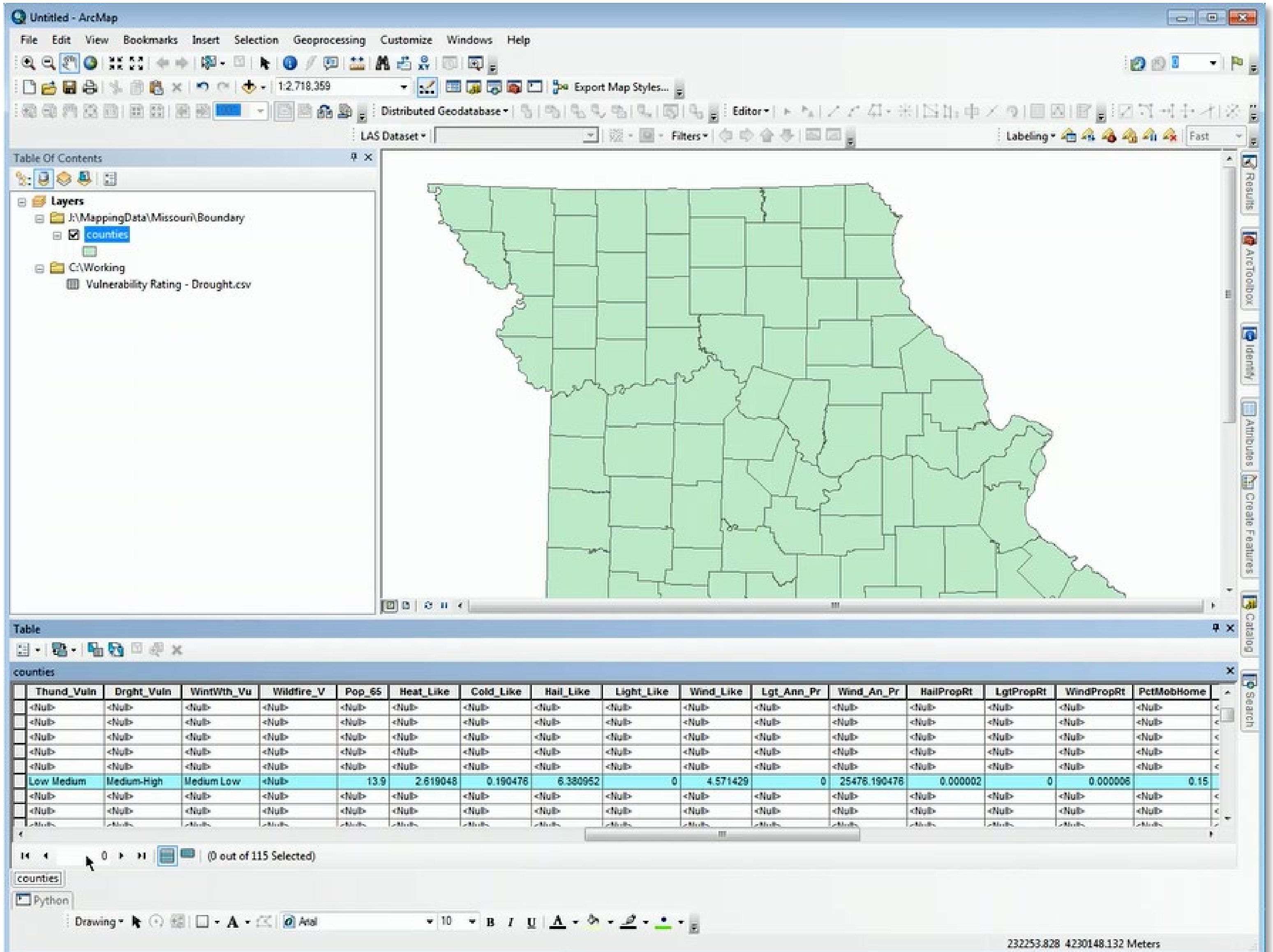
e) Choose "**Keep all records**"

f) Choose "**Validate Join**"

g) Click "**Ok**" at the bottom.



5) The data in the CSV file will now appear appended to the right of the County file attributes. For counties with no data in the CSV file, the attributes are <Null>.



Appendix C: EMAP Hazard Identification, Risk Assessment, and Consequence Analysis

The Emergency Management Accreditation Program (EMAP) is an independent non-profit organization that applies a standards-based voluntary assessment and peer review accreditation process for government programs responsible for coordinating prevention, mitigation, preparedness, response and recovery activities for natural and human caused disasters. Accreditation is based on compliance with collaboratively developed national standards, the Emergency Management Standard by EMAP. As part of the State of Missouri EMAP accreditation process, an analysis of the potential for detrimental impacts of hazards was conducted and integrated into the Plan. This information provides useful data to better assess risk and provide input for the development of mitigation strategies. This analysis was completed based on the 2019 Emergency Management Standard. This document is available at this link: http://www.emap.org/index.php/root/about-emap/96-emap-em-4-2016.

C.1. Overview and Methodology

Risk and Vulnerability Assessment Definitions

In accordance with EMAP criteria for Hazard Identification, Risk Assessment, and Consequence Analysis, this plan evaluates the risk and vulnerability of people, property, the environment, and operations for each identified hazard. These assets are defined as follows:

- People: The estimated population as obtained from the US Census Bureau. In addition, “people” includes identified vulnerable populations and, if applicable, data presentation of individuals within the impact area of the hazard.
- Property: Building exposure, as derived from inventory data associated with FEMA’s loss estimation software HAZUS-MH. Content values are also included and were estimated as a percentage of building value based on their property type, using FEMA/HAZUS estimated content replacement values. Additionally, structure count information was obtained from the MSDIS structure database.
- Environment: Agricultural resources, air quality, water bodies and water quality, native plant and animal species and habitats.
- Operations: Critical facilities and infrastructure and their continuity of service. A critical facility is defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. For Missouri state-owned or operated facilities provided by the Office of Administration, Missouri Department of Transportation (MoDOT), and Missouri Department of Conservation (MDC) the Mitigation Plan applied FEMA’s guidelines for determining critical facilities to the asset use/facility types. A total of 1,950 facilities were determined to be critical facilities. For the MoDOT State Bridge Inventory, all 10,400 state-owned bridges in Missouri were considered critical.

Risk Assessment Methodology

For each hazard, overall risk was assessed based on the hazard's probability and severity. Probability and severity were rated based on research of hazard characteristics, past occurrences, and probable future conditions. Input from the SRMT was also considered in the probability and severity determination process.

Probability is the likelihood that a hazard will occur and is determined based on either a statistical analysis of historical occurrences or a statistical analysis of probable occurrence. Probability was summarized as possible, likely, or highly likely, which are defined as follows:

- **Possible**—less than a 10% annual probability of occurrence
- **Likely**—greater than 10% but less than 100% annual probability of occurrence
- **Highly Likely**—100% or greater annual probability of occurrence

Severity is a general rating of the magnitude of impacts that could result from the hazard. Severity ratings are based on information on past occurrences and research on probable damages. Severity is report as low, moderate, or high, which are defined as follows:

- **Low**—Few or minor damages or injuries are likely.
- **Moderate**—Injuries to people and responders and damages to property and the environment are expected.
- **High**—Deaths and major injuries and damage will likely occur.

Probability and severity ratings were combined to determine an overall risk assessment rating using the matrix below:

Probability				
	Highly Likely	Moderate	High	High
	Likely	Low	Moderate	High
	Possible	Low	Low	Moderate
		Low	Moderate	High
			Severity	

To assess the specific risk of people, property, environment, and operations to each of the identified hazards, this same methodology was used; however, severity ratings were assigned based on potential impacts to the specific asset in question. Impacts were evaluated based on past occurrences, known exposure, and hazard characteristics.

Vulnerability Assessment Methodology

The vulnerability of each asset was also assessed for each hazard to define exposure and potential losses. The methodology for assessing vulnerability varies by hazard and asset. Where possible, vulnerability is quantified. In most cases, the vulnerability of people and property are assessed by quantitative and/or spatial means, while the vulnerability of environment and operations relies on qualitative assessment. to provide an estimate of exposure, annualized losses, and/or potential loss.

Consequence Analysis Definitions

A consequence analysis was conducted for each hazard to consider its impacts on the following elements of the planning area: public, responders, continuity of operations including continued delivery of services; property, facilities and infrastructure; environment; economic condition of the jurisdiction; and public confidence in the jurisdiction's governance. These elements are defined as follows:

- Public: People who live in, work in, or visit the planning area.
- Responders: Federal, State, and local governmental and nongovernmental emergency public safety, fire, law enforcement, emergency response, emergency medical (including hospital emergency facilities), and related personnel, agencies, and authorities.
- Continuity of operations including continued delivery of services: Continuity of operations is the effort within the State of Missouri executive departments and agencies to ensure that primary mission essential functions continue to be performed during a wide range of emergencies, including localized acts of nature, accidents and technological or attack-related emergencies. Continued delivery of services refers to mission essential functions of the Missouri State Government. This includes transportation, communications, public works and engineering, firefighting, information and planning, mass care, logistics, public health, search and rescue, oil and hazmat response, agriculture and natural resources, energy, public safety and security, cyber security, and external affairs.
- Property, facilities, and infrastructure: Property is defined as building exposure within the State of Missouri. Facilities are the critical facilities essential in providing utility or direction either during the response to an emergency or during the recovery operation. Infrastructure includes assets of the Missouri Department of Transportation (MoDOT), including the State Bridge Inventory.
- Environment: Agricultural resources, air quality, water quality, as well as natural resources requiring remediation.
- Economic condition of the jurisdiction: Defined as the State of Missouri's Gross Domestic Product (GDP).
- Public confidence in the jurisdiction: Refers to the level of trust of the State of Missouri's government and potential for distrust through mistakes or inefficiencies in responding to and recovering from a disaster event.

Consequence Analysis Methodology

The consequence analysis was prepared using a rubric to rate potential consequences to each element on a scale of 0-3. Below is a description of each element and their associated consequence scoring.

Public
0 - N/A
1 - Minimal, hazard results in mild injuries
2 - Moderate, hazard results in several severe injuries and deaths
3 - Severe, hazard results in mass casualty event with multiple deaths and severe injuries

Responders

0 - N/A

1 - Minimal, hazard results in mild injuries

2 - Moderate, hazard results in several severe injuries and deaths among responders

3 - Severe, hazard results in multiple deaths and severe injuries among responders

Continuity of Operations

0 - N/A

1 - Minimal, hazard results in no or limited need for COOP activation

2 - Moderate, hazard results in the potential need for COOP activation, but no longer than thirty (30) days

3 - Severe, hazard results in potential need for COOP activation, may last beyond thirty (30) days

Property, Facilities, and Infrastructure

0 - N/A

1 - Minimal, hazard results in localized damage to property, but infrastructure is not seriously affected

2 - Moderate, hazard results in significant property damage and infrastructure is somewhat affected

3 - Severe, hazard results in widespread and extensive property damage and infrastructure is significantly affected

Environment

0 - N/A

1 - Minimal, hazard results in limited or localized environmental impacts

2 - Moderate, hazard results in impacts that reach beyond the local area, requiring monitoring or cleanup

3 - Severe, hazard results in widespread impacts, requiring extensive monitoring or cleanup operations

Economy

0 - N/A

1 - Minimal, hazard results in losses of less than 1% of Missouri's Gross Domestic Product (GDP)

2 - Moderate, hazard results in losses between 1% and 3% of Missouri's GDP

3 - Severe, hazard results in losses of 3% or more of Missouri's GDP

Public Confidence

0 - N/A

1 - Minimal, hazard results in mistakes or inefficiencies that generate no perceptible impact

2 - Moderate, hazard results in mistakes or inefficiencies that generate some distrust

3 - Severe, hazard results in mistakes or inefficiencies that generate major distrust

Scores for each element were summed to generate a total consequence score. Total scores ranged from a high of 21 (the maximum possible) to a low of 8. Based on these results, the total scores were divided into the following three quantiles to reflect the relative rating of consequences for each hazard:

- High: Total consequence scores from 21-20
- Moderate: Total consequence scores from 19-14
- Low: Total consequence scores from 13-8

C.2. EMAP Hazard Identification, Risk Assessment, and Consequence Analysis Results

Overview

This section summarizes the hazards that were identified for inclusion in this Hazard Mitigation Plan Update as well as the overall results of the EMAP risk assessment and consequence analysis for each hazard.

Table 3.1. EMAP Summary Results

Hazard	Risk Rating	Consequence Analysis Rating
Flooding	High	High
Levee Failure	High	High
Dam Failure	Moderate	High
Earthquake	High	High
Land Subsidence/Sinkholes	Moderate	Low
Drought	High	Low
Extreme Temperatures	High	Low
Severe Thunderstorm (includes Damaging Winds, Hail, and Lightning)	High	Low
Severe Winter Weather	High	Moderate
Tornadoes	High	High
Wildfires	Moderate	Moderate
Civil Disorder	Low	Moderate
Cyber Disruption	Moderate	Low
Environmental Health Emergencies	Low	Low
Structural and Urban Fires	High	Low
Hazardous Materials Release (Fixed Facility and Transportation Accidents)	High	Moderate
Mass Transportation	High	Moderate
Nuclear Power Plants	Moderate	High
Public Health Emergencies	Low	Moderate
Special Events	Moderate	Low
Terrorism	Moderate	High

Hazard	Risk Rating	Consequence Analysis Rating
Utilities (Interruptions and System Failures)	Low	Moderate

Detailed results of the EMAP analyses are presented below by hazard. Each hazard section includes specific risk and vulnerability assessment findings for each evaluated asset as well as consequence analysis scores for each evaluated element.

Flooding

See the Flooding hazard profile in Section 3.3.1 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing flooding risk combined quantitative and qualitative approaches. Past event narratives, disaster declarations, and flood insurance claim data were reviewed to assess expected impacts. Past crop insurance claims were also reviewed to quantify some of the environmental impacts of past floods.

Table 3.2. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	High – Flooding has caused significant impacts to people, including numerous evacuations. Deaths and injuries have resulted from flooding in Missouri.	High
Property	Highly Likely (100%)	High – Missouri has sustained 47,700 flood insurance claims resulting in a total of $813,050,620 in claims payments.	High
Environment	Highly Likely (100%)	Moderate – From 2012-2016, $777,866,981 in crop losses were reported due to flooding.	High
Operations	Highly Likely (100%)	Moderate – Flooding may impact roads and utilities, required major response operations, and necessitated repairs to critical infrastructure.	High
Overall	Highly Likely (100%)	High	High

Vulnerability Assessment

The methodology for assessing flooding vulnerability included a spatial analysis of exposure, an estimation of losses, and a review of historical damages. A GIS analysis was performed using FEMA's Hazus software to model flood vulnerability and estimate flood losses. Population at risk was estimated based on the number of at-risk residential properties and average household size. Past crop insurance claims were reviewed to estimate annualized loss to crops.

Table 3.3. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	It is estimated that more than 43,486 households are within the Special Flood Hazard Area across the State. Hazus results indicate that approximately 137,715 people would be affected by a 1% annual chance flood event based on residential exposure. An estimated 194,043 people would be displaced by the 1% annual chance flood event and 96,635 would need shelter.

Subject	Exposure, Annualized Loss, and/or Potential Losses
Property	An estimated $7,304,914,000 in structural damage would result from the 1% annual chance flood event. An estimated 5,833 structures would be substantially damaged.
Environment	Annualized losses to crops are estimated at $155,573,396.
Operations	Damage to facilities/personnel in the area of a flood may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services.

Consequence Analysis

The overall consequence score for levee failure is 20, which is rated as high consequence.

Table 3.4. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	3 – Severe
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Levee Failure

See the Levee Failure hazard profile in Section 3.3.2 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing levee failure risk combined quantitative and qualitative approaches. Past event narratives were reviewed to provide a qualitative assessment of the expected impacts from levee failure. Additionally, a GIS analysis was performed to evaluate levee protected areas in the National Flood Hazard Layer and the National Levee Database against HAZUS/MSDIS exposure data for values, numbers, and types of structures at risk. Population at risk was estimated based on the number of residential properties in protected areas and the average household size according to Census data. These exposure numbers provided context for evaluating the potential severity of impacts.

Table 3.5. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	High – Past levee failures have resulted in significant impacts to people, including numerous evacuations. Deaths have resulted from flooding in Missouri. Thousands of residential structures are located in levee protected areas.	High
Property	Highly Likely (100%)	High – Past levee failures have resulted in hundreds of millions of dollars in damages to property in Missouri. Thousands of structures are located in levee protected areas.	High
Environment	Highly Likely (100%)	Moderate – Past levee failures have resulted in hundreds of millions of dollars in damages to crops and agriculture in Missouri.	High

Subject	Probability	Severity	Overall Risk
Operations	Highly Likely (100%)	Moderate – Past levee failures have resulted in flooding of roads, required major flooding response operations, and necessitated repairs to critical infrastructure.	High
Overall	Highly Likely (100%)	Moderate	High

Vulnerability Assessment

The methodology for assessing levee failure vulnerability included a spatial analysis of exposure, an estimation of losses, and a review of historical damages noted in past event narratives. A GIS analysis was performed to evaluate levee protected areas in the National Flood Hazard Layer and the National Levee Database against HAZUS/MSDIS exposure data for values, numbers, and types of structures at risk. Utilizing an assumed depth-damage percentage of 50-percent, the building loss estimate for failure of levee segments designed to provide 1-percent-annual-chance flood protection was computed. Estimates of population affected were based on the number of affected residential properties and the average household size according to Census data.

Table 3.6. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	An estimated 128,558 people live in buildings estimated to be damaged by levee failure.
Property	An estimated 95,082 buildings, with a total structure value of $29,818,812,980 are estimated to be damaged by levee failure.
Environment	Levee failure could cause significant losses to agricultural crops. One past event resulted in nearly $1 billion in crop damages. Additional costs due to water quality and habitat impacts are possible but could not be estimated.
Operations	Damage to facilities/personnel in the area of a failure may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services.

Consequence Analysis

The overall consequence score for levee failure is 20, which is rated as high consequence.

Table 3.7. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	3 – Severe
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Dam Failure

See the Dam Failure hazard profile in Section 3.3.3 for more detail on the overall risk and vulnerability assessments, including data sources, past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing dam failure risk combined quantitative and qualitative approaches. Past event narratives were reviewed to assess the expected impacts from dam failure. Additionally, a GIS analysis was performed to evaluate dam inundation areas for State-regulated Class 1 and Class 2 dams as well as USACE dams against HAZUS/MSDIS building exposure data for values, numbers, and types of structures at risk. Population at risk was estimated based on the number of residential properties in protected areas and the average household size according to Census data. These exposure numbers provided context for evaluating the potential severity of impacts.

Table 3.8. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Likely (45%)	High – Approximately 1,511 dams in Missouri are high hazard, meaning loss of life would be likely if they failed. Over 150,000 people live in dam inundation areas. Past dam failures have resulted in significant impacts to people, including evacuations and injuries.	High
Property	Likely (45%)	High – Past dam failures have caused property damages. Over 124,000 structures are located in dam inundation areas.	Moderate
Environment	Likely (45%)	Moderate – Past dam failures have resulted in damages to State park lands. The loss of a reservoir can destroy fish and wildlife habitat and be detrimental to water supply and water quality.	Moderate
Operations	Likely (45%)	Moderate – Past dam failures have caused road and infrastructure damage.	Moderate
Overall	Likely (45%)	Moderate	Moderate

Vulnerability Assessment

The methodology for assessing dam failure vulnerability included a spatial analysis of exposure, an estimation of losses, and a review of historical damages noted in past event narratives. A GIS analysis was performed to evaluate dam inundation areas for State-regulated Class 1 and Class 2 dams as well as USACE dams against HAZUS/MSDIS building exposure data for values, numbers, and types of structures at risk. To determine estimates of potential loss, a damage estimation of 20 percent of the total structure value in dam inundation areas was used. Estimates of population exposure were based on the number of residential buildings located in dam inundation areas and the average household size according to Census data.

Table 3.9. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	An estimated 151,845 people live in dam inundation areas and are exposed to potential dam failure.
Property	An estimated 124,879 buildings, with a total structure value of $55,006,212,998 are exposed to dam failure. The loss estimate for property that could be affected by dam failure is $9,604,501,762.
Environment	Dam failure could cause significant losses to the environment, including loss of reservoirs and the uses they provide, which include flood control, erosion control, recreation, fish and wildlife habitat, water supply, and water quality improvement. Additional costs due to water quality and habitat impacts are possible but could not be estimated.

Subject	Exposure, Annualized Loss, and/or Potential Losses
Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.

Consequence Analysis

The overall consequence score for dam failure is 21, which is rated as high consequence.

Table 3.10. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	3 – Severe
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	3 – Severe
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Earthquakes

See the Earthquakes hazard profile in Section 3.3.4 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing earthquakes combined quantitative and qualitative approaches. Past event narratives were reviewed to assess the expected impacts from earthquakes. Additionally, a summary of past earthquakes and their magnitudes helped understand the annual probability of an earthquake with a particular magnitude. This was used to estimate the potential effects of different earthquake severities. The Richter Magnitude and Modified Mercalli Intensity Scales helped classify the potential extent of damages and injuries expected to occur given various magnitudes.

Table 3.11. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Likely (72%)	Low – The majority of past earthquakes have not resulted in a high number of deaths or injuries. The probability of more severe incidents would not result in high loss of human life	Low
Property	Likely (72%)	High – Past earthquake events have resulted in substantial damages to property in Missouri. Thousands of structures are in earthquake-prone areas.	High
Environment	Likely (72%)	Moderate – Past earthquakes have caused the ground to sink, lake formation, and soil liquification that can cause environmental damage.	Moderate
Operations	Likely (72%)	High – Past earthquakes have resulted in damaged roads and utilities, required repairs to critical infrastructure.	High
Overall	Likely (72%)	High	High

Vulnerability Assessment

HAZUS was used to analyze vulnerability and estimate losses to earthquakes. Two scenarios were used to calculate potential losses. An annualized loss scenario synthesized from a FEMA nationwide study was used to estimate direct annualized economic losses to buildings (FEMA 366 HAZUS Estimated Annualized Earthquake Losses for the United States April 2017). A second scenario, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst-case earthquake. Level 2 building inventory and census data was used to enhance the accuracy of earthquake hazard modeling.

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	An estimated 28,292 injuries and 1, 606 fatalities
Property	An estimated 136,432 buildings with extensive damage or completely destroyed, with a total building loss of 7.6 billion.
Environment	Secondary effects such as soil liquefaction, fires, building collapse, dam failures, flooding, and hazardous material releases could cause crop damage or pollution of environmental resources.
Operations	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.

Consequence Analysis

The overall consequence score for earthquakes is 21, which is rated as high consequence.

Table 3.12. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	3 – Severe
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	3 – Severe
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Land Subsidence and Sinkholes

See the Land Subsidence and Sinkholes hazard profile in Section 3.3.5 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing land subsidence and sinkholes risk combined quantitative and qualitative approaches. Past event narratives were reviewed to provide a qualitative assessment of the expected impacts from land subsidence and sinkholes. Additionally, the sinkhole hazard layer was used in conjunction with the Missouri Spatial Data Inventory Service (MSDIS) structure file to determine structures that fall within sinkhole areas as well as structures that are within a buffered distance of 50 feet of sinkholes. An estimated population impacted for each county was calculated based on the number of residential properties in the buffered areas multiplied by the average household size.

Table 3.13. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Low – Past sinkhole events have resulted in few deaths and injuries. Localized impact expected to be moderate to light for incident areas and light for other adversely affected areas.	Moderate
Property	Highly Likely (100%)	Low – Historically, sinkholes occur in areas away from development and typically do not cause serious damage.	Moderate
Environment	Highly Likely (100%)	High – Pollutants captured in sinkholes can affect a community's groundwater system, they can also cause lakes and other waterbodies to drain.	High
Operations	Highly Likely (100%)	Moderate – Past sinkholes have damaged infrastructure like roads, parking lots, water mains, and lift stations. Some localized, but severe damage is possible.	High
Overall	Highly Likely (100%)	Low	Moderate

Vulnerability Assessment

The methodology for assessing land subsidence and sinkhole vulnerability included a spatial analysis of exposure, an estimation of losses, and a review of historical damages noted in past event narratives. A GIS analysis was performed to evaluate known sinkhole areas from the sinkhole inventory created by MoDNR's Missouri Geological Survey. This layer was used in combination with the MSDIS structure file to analyze the number of structures, the value of structures, and the population within a buffered distance of 50 feet of sinkholes in order to estimate potential impacts and losses from sinkholes.

Table 3.14. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	An estimated 14,168 people live in buildings with the potential to be impacted by sinkholes.
Property	An estimated 7,122 buildings, with a total structure value of $1,778,874,949 have the potential to be impacted by sinkholes.
Environment	Depending on the size and location, groundwater contamination and the absorption of waterbodies is possible. Impacts will likely be localized.
Operations	Damage to facilities/personnel in a localized area may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services.

Consequence Analysis

The overall consequence score for land subsidence and sinkholes is 8, which is rated as low consequence.

Table 3.15. Consequence Analysis Results

Subject	Consequence Score
Public	1 – Minimal
Responders	1 – Minimal
Continuity of Operations including Continued Delivery of Services	1 – Minimal
Property, Facilities, and Infrastructure	2 – Moderate
Environment	1 – Minimal
Economic Condition of Jurisdiction	1 – Minimal

Subject	Consequence Score
Public Confidence in the Jurisdiction's Governance	1 – Minimal

Drought

See the Drought hazard profile in Section 3.3.6 for more detail on the overall risk and vulnerability assessments, including data sources, past occurrences, and annualized loss calculations.

Risk Assessment

The methodology for assessing drought risk involved a review of past drought impact summaries, typical and experienced impacts according to the National Drought Mitigation Center's Drought Impact Reporter, and data on past crop insurance claims reported by the USDA Risk Management Agency. Social vulnerability was also considered in evaluating the risk of drought to the public.

Table 3.16. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Likely (6-11%)	Moderate – Drought can cause public health problems related to reduced water quantity and quality. Most severely affected are rural areas served by small water supply structures.	Moderate
Property	Likely (6-11%)	Low – In areas prone to expansive soils, drought can trigger movement that can damage foundations and infrastructure.	Low
Environment	Likely (6-11%)	High – Drought causes significant agricultural damages. From 2007-2016, drought resulted in $1,495,192,901 in crop insurance claims.	High
Operations	Likely (6-11%)	Moderate – Drought impacts water supply and quality which can cause a variety of impacts on critical facilities and infrastructure. Reservoirs may face potential erosion and damage due to low water levels. Barge traffic on the Missouri and Mississippi Rivers has been interrupted by obstructions and low water levels.	Moderate
Overall	Likely (6-11%)	High	High

Vulnerability Assessment

The methodology for assessing drought vulnerability included a review of damages reported in past drought narratives as well as a review of crop exposure data reported in the 2017 Census of Agriculture and crop insurance claim data reported by the USDA Risk Management Agency. Although impacts vary by location, drought is not spatially confined; therefore, the entire population is considered exposed to drought.

Table 3.17. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	Drought can affect all 6,168,187 people living in Missouri.
Property	Property in areas with expansive soils may be directly impacted by drought; this exposure level could not be quantified. Individual foundation repairs can cost tens of thousands of dollars.
Environment	Based on past crop insurance claims data for drought, annualized losses are estimated at $354,098,203. Crop exposure across the state totals $502,047,016.00
Operations	Water utilities and water supply infrastructure are considered exposed to drought.

Consequence Analysis
The overall consequence score for drought is 9, which is rated as low consequence.

Table 3.18. Consequence Analysis Results

Subject	Consequence Score
Public	1 – Minimal
Responders	1 – Minimal
Continuity of Operations including Continued Delivery of Services	1 – Minimal
Property, Facilities, and Infrastructure	1 – Minimal
Environment	2 – Moderate
Economic Condition of Jurisdiction	2 – Moderate
Public Confidence in the Jurisdiction's Governance	1 – Minimal

Extreme Temperatures
See the Extreme Temperatures hazard profile in Section 3.3.7 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment
The methodology for assessing extreme temperatures risk combined quantitative and qualitative approaches. Past event narratives were reviewed to provide a qualitative assessment of the expected impacts from extreme cold and extreme heat. Additionally, the NCEI Storm Events Database was used to assess the annual total of events, deaths, injuries, property damages, and crop damages that have occurred since 1996. Data from the Missouri Department of Health and Senior Services (DHSS) was also used to assess heat-related hospital visits and both hyperthermia and hypothermia mortality cases. Both the NCEI data and the DHSS studies provided context for evaluating the potential severity of impacts and probability of occurrence.

Table 3.19. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Moderate – Past extreme weather events have resulted in significant impacts to people, including heat exhaustion, and hypothermia/hyperthermia. Deaths and hospitalization have resulted from extreme temperatures, particularly extreme heat.	High
Property	Highly Likely (100%)	Low – Extreme temperatures can cause building materials to expand and contract which may cause fractures or other damages. Past occurrences have resulted in minimal costs.	Moderate
Environment	Highly Likely (100%)	High – Past extreme temperature events have resulted in hundreds of millions of dollars in damages to crops and agriculture in Missouri.	High
Operations	Highly Likely (100%)	Moderate – Past extreme temperature events have resulted in damaged electrical utilities and pipes, that necessitated repairs to critical infrastructure.	High
Overall	Highly Likely (100%)	Moderate	High

Vulnerability Assessment

The methodology for assessing extreme temperatures vulnerability included a statistical analysis of vulnerability characteristics, an estimation of losses, and a review of historical impacts noted in past event narratives and studies. From the statistical data collected, four factors were considered in determining overall vulnerability to extreme temperatures: total population, percentage of population over 65, likelihood of occurrence, and social vulnerability. The methodology used data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2016), total population and percentage of population over 65 data from the U.S. Census (2015 ACS), and the calculated Social Vulnerability Index for Missouri counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

Table 3.20. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	An estimated average of 17.8% of the population is over the age of 65 and over 70% of the counties are classifies as having high to medium social vulnerability ratings.
Property	Minimal impacts on property. Older buildings made of aging materials may be more vulnerable to extreme temperatures and drastic changes.
Environment	Extreme temperatures could cause significant losses to agricultural crops. One past event resulted in nearly $1.69 million in crop damages. Additional costs due to water quality and habitat impacts are possible but could not be estimated.
Operations	Localized disruption of roads and/or utilities may occur due to ice, or blackout from overburdened electrical grid.

Consequence Analysis

The overall consequence score for extreme temperatures is 9, which is rated as low consequence.

Table 3.21. Consequence Analysis Results

Subject	Consequence Score
Public	2 – Moderate
Responders	1 – Minimal
Continuity of Operations including Continued Delivery of Services	1 – Minimal
Property, Facilities, and Infrastructure	2 – Moderate
Environment	1 – Minimal
Economic Condition of Jurisdiction	1 – Minimal
Public Confidence in the Jurisdiction's Governance	1 – Minimal

Severe Thunderstorms (includes Damaging Winds, Hail, and Lightning)

See the Severe Thunderstorms hazard profile in Section 3.3.8 for more detail on the overall risk and vulnerability assessments, including data sources, past occurrences, and annualized loss.

Risk Assessment

The methodology for assessing severe thunderstorm risk involved a review of past event impacts as reported in NOAA's NCEI Storm Events Database, which compiles records on storm impacts, included deaths, injuries, property damages, and crop damages that have resulted from past events. Event

narratives were also reviewed. Social vulnerability was also considered in evaluating the risk of severe thunderstorms, particularly wind, to the public.

Table 3.22. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Moderate – Since 1996, severe thunderstorms have caused 60 death and over 500 injuries in Missouri.	High
Property	Highly Likely (100%)	Moderate – Since 1996, severe thunderstorms have caused $1,457,627,830 in property damages in Missouri. Roof damage from wind and hail is common. Lightning may cause structural fires.	High
Environment	Highly Likely (100%)	Moderate – According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of hail conditions for the 10-year period of 2012 – 2021 totaled $12,231,579. During this same period, insured crop losses for wind/excess wind were $15,893,749.	High
Operations	Highly Likely (100%)	Low – Power outages may affect critical facility operations. Downed trees and branches may block roads.	Moderate
Overall	Highly Likely (100%)	Moderate	High

Vulnerability Assessment

The methodology for assessing severe thunderstorm vulnerability included a review of damages reported in past event narratives as well as a review of crop exposure data reported in the 2017 Census of Agriculture and crop insurance claim data reported by the USDA Risk Management Agency. Individual storm impacts are localized, but the entire population is considered exposed to severe weather.

Table 3.23. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	Severe thunderstorms can affect all 6,168,187 people living in Missouri. People living in mobile homes are more vulnerable to high-winds.
Property	According to NCEI Storm Events Database records from 1996-2016, annualized loss to property from severe thunderstorm winds, hail, and lightning are $12,106,933, $43,564,933, and $390,742, respectively. Mobile homes are particularly vulnerable to wind damage.
Environment	According to USDA Risk Management Agency records of crop insurance claims from 2012-2021, annualized crop loss from severe thunderstorm winds and hail are $15,893,749 and $12,231,579, respectively.
Operations	Localized facility damage may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.

Consequence Analysis

The overall consequence score for severe thunderstorms is 12, which is rated as low consequence.

Table 3.24. Consequence Analysis Results

Subject	Consequence Score
Public	2 – Moderate
Responders	1 – Minimal
Continuity of Operations including Continued Delivery of Services	2 – Moderate
Property, Facilities, and Infrastructure	2 – Moderate

Subject	Consequence Score
Environment	3 – Severe
Economic Condition of Jurisdiction	1 – Minimal
Public Confidence in the Jurisdiction's Governance	1 – Minimal

Tornadoes

See the Tornadoes hazard profile in Section 3.3.10 for more detail on the overall risk and vulnerability assessments, including data sources, past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing tornado risk involved a review of past event impacts as reported in NOAA's NCEI Storm Events Database, which compiles records on storm impacts, included deaths, injuries, property damages, and crop damages that have resulted from past events. Event narratives were also reviewed. Social vulnerability was also considered in evaluating the risk of tornado to the public.

Table 3.25. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	High – Since 1950, severe thunderstorms have caused 402 deaths and 4,489 injuries in Missouri.	High
Property	Highly Likely (100%)	High – Since 1950, tornados have caused $5.3 billion in property damages in Missouri.	High
Environment	Highly Likely (100%)	High – Data on the dollar value of past damages was not evaluated, but crop damage is common.	High
Operations	Highly Likely (100%)	High – Tornados have caused major damages and disruptions to critical facilities and infrastructure operations, including problems with drinking water, utilities and power lines, debris removal, and sheltering. Damaged facilities will necessitate temporary relocation of some critical functions.	High
Overall	Highly Likely (100%)	High	High

Vulnerability Assessment

The methodology for assessing tornado vulnerability included a statistical analysis of HAZUS building data, population density, mobile home data, social vulnerability, and storm events data. A qualitative analysis of past event narratives was also used to assess vulnerabilities. Individual storm impacts are localized, but the entire population is considered exposed to severe weather.

Table 3.26. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	Tornado can affect all 6,168,187 people living in Missouri. Tornados cause an average of 5.9 deaths and 66.1 injuries annually. Areas with greater population densities and/or higher numbers of mobile homes may experience more severe impacts.
Property	Annualized loss to property is estimated at $74,088,993.
Environment	Agriculture, including crops and livestock, are vulnerable to tornado damages. Water quality and air quality are vulnerable to contamination in the event that hazmat facilities are damaged.

Subject	Exposure, Annualized Loss, and/or Potential Losses
Operations	Power lines are highly vulnerable to tornado impacts. Water supply infrastructure is also particularly vulnerable. Additional facilities and infrastructure may be impacted by power outages.

Consequence Analysis

The overall consequence score for tornadoes is 21, which is rated as high consequence.

Table 3.27. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	3 – Severe
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	3 – Severe
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Severe Winter Weather

See the Severe Winter Weather hazard profile in Section 3.3.9 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing severe winter weather risk combined quantitative and qualitative approaches. Past event narratives were reviewed to provide a qualitative assessment of the expected impacts from severe winter weather. Additionally, NCEI data was assessed and annualized to understand probability and severity of past severe winter weather events.

Table 3.28. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Moderate – Past severe winter weather has caused some injuries and deaths primarily due to unsafe road conditions. However, large incidents with high injury/fatality are not expected.	High
Property	Highly Likely (100%)	Moderate – Past severe winter weather has caused tens of millions of dollars in damages to property in Missouri.	High
Environment	Highly Likely (100%)	Moderate – Past winter storms have resulted in damages to crops and agriculture in Missouri.	High
Operations	Highly Likely (100%)	Moderate – Past severe winter weather has resulted in unsafe roads, required response operations, and necessitated repairs to critical infrastructure.	High
Overall	Highly Likely (100%)	Moderate	High

Vulnerability Assessment

The methodology for assessing levee failure vulnerability included a review of historical damages noted in past event narratives, and a statistical analysis using a range of data that reflect potential vulnerability. For the statistical analysis, five factors were considered in determining overall vulnerability

to severe winter weather, housing density, building exposure, social vulnerability, likelihood of occurrence, and average annual property loss. The analysis used data from several sources: NCEI storm events, HAZUS Building Exposure Value data, housing density data from the U.S. Census, and the calculated Social Vulnerability Index for Missouri counties.

Table 3.29. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	Over 70% of the counties are classifies as having high to medium social vulnerability ratings.
Property	Across all the counties, the average annualized property loss is just under $35,922,028.
Environment	Severe winter weather could cause significant losses to agricultural crops.
Operations	Damage to facilities/personnel in the area of a severe winter weather may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services.

Consequence Analysis

The overall consequence score for severe winter weather is 15, which is rated as high consequence.

Table 3.30. Consequence Analysis Results

Subject	Consequence Score
Public	2 – Moderate
Responders	1 – Minimal
Continuity of Operations including Continued Delivery of Services	2 – Moderate
Property, Facilities, and Infrastructure	2 – Moderate
Environment	3 – Severe
Economic Condition of Jurisdiction	2 – Moderate
Public Confidence in the Jurisdiction’s Governance	3 – Severe

Wildfires

See the Wildfires hazard profile in Section 3.3.11 for more detail on the overall risk and vulnerability assessments, including data sources, past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing wildfire risk involved a review of information from the Missouri Department of Conservation, including historical wildfire data.

Table 3.31. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Low – Past wildfire events have destroyed homes and required large evacuations of at-risk communities.	Moderate
Property	Highly Likely (100%)	High – From 2012 to 2016, 1,172 buildings were damaged by wildfire in Missouri.	High
Environment	Highly Likely (100%)	High – From 2004 to 2016, 657,731 acres burned due to wildfire.	High

Subject	Probability	Severity	Overall Risk
Operations	Highly Likely (100%)	Moderate – Wildfires can damage critical facilities and infrastructure in at-risk areas and can overwhelm local firefighting capacity. Approximately 700 rural fire departments have regional mutual aid agreements and over 300 have mutual aid agreements with the State to obtain assistance in wildfire protection if needed.	High
Overall	Highly Likely (100%)	Low to Moderate	Moderate

Vulnerability Assessment

The methodology for assessing wildfire vulnerability included a GIS comparative analysis of wildland urban interface and intermix (WUI) areas against building exposure data to determine the types, numbers, and estimated values of buildings at risk to wildfire. This GIS-based analysis utilized data from the Missouri Spatial Data Inventory Service (MSDIS), HAZUS building exposure value data, and wildland urban interface and intermix area data from the University of Wisconsin-Madison SILVIS Lab. To calculate estimated values of buildings at risk, buildings values available in the HAZUS census block data were used to determine an average value for each property type. This average value per property type was then applied to the number of structures in the WUI areas, by type, to calculate an overall estimated value of buildings at risk by type. Estimated population impacted was calculated based on the number of residential properties in the WUI areas multiplied by the average household size.

Table 3.32. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	An estimated 1,205,777 people are exposed to wildfire risk.
Property	An estimated 595,042 buildings with a total value of $139,904,614,533 are exposed to wildfire risk.
Environment	Forests cover about one third of the state and are highly vulnerable to wildfire.
Operations	Power lines are highly vulnerable to wildfire. Additional facilities and infrastructure may be impacted by power outages. Firefighters are also vulnerable when responding to wildfires.

Consequence Analysis

The overall consequence score for wildfire is 17, which is rated as moderate consequence.

Table 3.33. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	2 – Moderate
Property, Facilities, and Infrastructure	2 – Moderate
Environment	3 – Severe
Economic Condition of Jurisdiction	2 – Moderate
Public Confidence in the Jurisdiction’s Governance	3 – Severe

Environmental Health Emergencies

See the Environmental Health Emergencies hazard profile in Section 3.3.14 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing environmental health emergencies risk involved a review of past environmental health incidents, and an assessment of the EPA's Toxic Release Inventory (TRI) data for Missouri facilities.

Table 3.34. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Possible (<1%)	Moderate – Past events have exposed people to harmful chemicals and poor air quality that can lead to health complications. Depending on the pollutant and medium, impacts can be localized.	Low
Property	Possible (<1%)	Low – Property may not be physically damaged but may require inspection and clean-up after exposure to chemicals or pollutants.	Low
Environment	Possible (<1%)	High – Past events have led to tens of thousands of acres of waterbodies to be polluted by harsh and unsafe substances that have impacted animals and humans.	Moderate
Operations	Possible (<1%)	Moderate – Past environmental health emergencies have resulted in contaminated water supply and necessitated response and cleanup of critical infrastructure.	Low
Overall	Possible (<1%)	Moderate	Low

Vulnerability Assessment

The methodology for assessing environmental health emergencies vulnerability included a review of historical events noted in past occurrences and a review of the Missouri Department of Natural Resources 2020 Missouri Integrated Water Quality Repot to estimate potential losses.

Table 3.35. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	The entire state is vulnerable to environmental health emergencies, however young children, and people who live in close proximity to industrial sites and transportation corridors are more vulnerable to poor air quality and potential water pollution.
Property	Properties are not vulnerable to physical damage from environmental emergencies.
Environment	Over $100 million in funding and grants is used to monitor, control, and mitigate water and air pollution in Missouri. An annual average of $24 million is given to landowners to address agricultural pollution and harmful runoff into the waterways.
Operations	Water supply infrastructure and personnel require continual and incident-related response to protect clean water supply.

Consequence Analysis

The overall consequence score for environmental health emergencies is 12, which is rated a low consequence.

Table 3.36. Consequence Analysis Results

Subject	Consequence Score
Public	1 – Minimal
Responders	1 – Minimal

Subject	Consequence Score
Continuity of Operations including Continued Delivery of Services	2 – Moderate
Property, Facilities, and Infrastructure	1 – Minimal
Environment	3 – Severe
Economic Condition of Jurisdiction	1 – Minimal
Public Confidence in the Jurisdiction's Governance	3 – Severe

Civil Disorder

See the Civil Disorder hazard profile in Section 3.3.12 for more detail on overall risk and vulnerability.

Risk Assessment

The methodology for assessing civil disorder risk involved a review of past events. Civil disorder research was also consulted to better understand when civil disorders typically occur, where they tend to form, and how they are escalated. This qualitative assessment summarized the expected impacts from civil disorder.

Table 3.37. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Possible (<1%)	Moderate – Past civil disorder events have resulted in significant impacts to people, including injuries and deaths. Impacts are localized	Low
Property	Possible (<1%)	Moderate – Past civil disorder events have resulted in millions of dollars in damages to property in Missouri. Typically, property in the immediate vicinity of the event.	Low
Environment	Possible (<1%)	Low – Civil disorders or large gatherings may cause localized damage in isolated cases.	Low
Operations	Possible (<1%)	Low – Past civil disorder events have resulted in significant impacts to response operations.	Low
Overall	Possible (<1%)	Moderate	Low

Vulnerability Assessment

The methodology for assessing civil disorder vulnerability included an estimation of historical damages noted in past events. Loss estimates were evaluated by examining recent civil disorder events that have occurred throughout Missouri.

Table 3.38. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	Recent civil disorder events resulted in over 80 arrests and tens of people injured.
Property	Recent unrest resulted in $5.7 million in property damage and 20+ burned and looted buildings.
Environment	Civil disorder could cause localized impacts from large gatherings and debris. Impacts depend on type of event and magnitude.
Operations	Localized disruption of roads may postpone delivery of some services. First responders are typically overburdened during civil disorder.

Consequence Analysis

The overall consequence score for civil disorder is 14, which is rated as moderate consequence.

Table 3.39. Consequence Analysis Results

Subject	Consequence Score
Public	2 – Moderate
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	2 – Moderate
Property, Facilities, and Infrastructure	2 – Moderate
Environment	1 – Minimal
Economic Condition of Jurisdiction	2 – Moderate
Public Confidence in the Jurisdiction's Governance	2 – Moderate

Cyber Disruption

See the Cyber Disruption hazard profile in Section 3.3.13 for more detail on overall risk and vulnerability.

Risk Assessment

The methodology for assessing cyber disruption risk involved a review of worldwide cyber attack statistics from Hackmageddon.

Table 3.40. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Low – Cyber disruption is unlikely to result in deaths or injuries. Theft of information is common but does not pose a direct threat to life safety.	Moderate
Property	Highly Likely (100%)	Low – Physical property is unlikely to be affected. Theft of information is common, and significant economic impacts could result from a cyber disruption. Financial impacts could also include ransoms for data and systems retrieval.	Moderate
Environment	Highly Likely (100%)	Low – Environmental impacts are not generally associated with cyber disruption.	Moderate
Operations	Highly Likely (100%)	High – Critical facilities and infrastructure operations could be significantly impacted by a cyber disruption, depending on the systems that are affected and their significance and connectivity.	High
Overall	Highly Likely (100%)	Low to High	Moderate

Vulnerability Assessment

The methodology for assessing cyber disruption vulnerability involved a qualitative assessment of hypothetical scenarios.

Table 3.41. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	The entire state population is vulnerable to cyber disruptions; however, impacts to individuals are typically limited to theft of data or lack of access to systems.

Subject	Exposure, Annualized Loss, and/or Potential Losses
Property	All buildings connected to public utilities and infrastructure could be vulnerable to impacts from cyber disruption in the event that these systems are targeted by a cyber attack.
Environment	Environmental assets are not vulnerable to cyber disruption.
Operations	All state critical facilities are vulnerable to cyber disruption. The most vulnerable systems are utility and infrastructure services that could be remotely accessed and controlled.

Consequence Analysis

The overall consequence score for wildfire is 9, which is rated as low consequence.

Table 3.42. Consequence Analysis Results

Subject	Consequence Score
Public	1 – Minimal
Responders	1 – Minimal
Continuity of Operations including Continued Delivery of Services	1 – Minimal
Property, Facilities, and Infrastructure	1 – Minimal
Environment	0 – Not Applicable
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	2 – Moderate

Structural and Urban Fires

See the Structural and Urban Fires hazard profile in Section 3.3.15 for more detail on overall risk and vulnerability.

Risk Assessment

The methodology for assessing structural and urban fire risk involved a review of data from the Missouri Division of Fire Safety, the National Fire Incident Reporting System, and the U.S. Fire Administration.

Table 3.43. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Moderate – From 2002 through 2016, 336,186 fires caused 5,311 injuries and 1,382 deaths in Missouri.	High
Property	Highly Likely (100%)	Moderate – Damages are expected, but the extent of damage can vary from minor to substantial and is highly dependent on individual structure characteristics and local fire department response capabilities.	High
Environment	Highly Likely (100%)	Low – Environmental damages are not expected.	Moderate
Operations	Highly Likely (100%)	Moderate – Fire departments, law enforcement offices, and other agencies spend considerable manpower and funding to respond to and investigate structural fires.	High
Overall	Highly Likely (100%)	Moderate	High

Vulnerability Assessment

The methodology for assessing structural and urban fire vulnerability involved a qualitative assessment of hypothetical scenarios.

Table 3.44. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	The entire state population is vulnerable to structural fires. Vulnerability varies by location based on structure characteristics, fire response capabilities, local enforcement of fire and building codes, and other factors. Annualized injuries and deaths are estimated at 354 and 92, respectively.
Property	Building vulnerability varies according to structure type and age, building codes, density of development, presence of flammable substances, water pressure and availability, and other factors. Annualized loss is estimated at $2,419,803,234.
Environment	Environmental assets are not vulnerable to structural or urban fires.
Operations	Localized disruption of roads and/or utilities caused by a fire may postpone delivery of services.

Consequence Analysis

The overall consequence score for structural and urban fire is 10, which is rated as low consequence.

Table 3.45. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	1 – Minimal
Property, Facilities, and Infrastructure	1 – Minimal
Environment	1 – Minimal
Economic Condition of Jurisdiction	1 – Minimal
Public Confidence in the Jurisdiction’s Governance	1 – Minimal

Hazardous Materials Release (Fixed Facility and Transportation Accidents)

See the Hazardous Materials Release hazard profile in Section 3.3.16 for more detail on overall risk and vulnerability.

Risk Assessment

The methodology for assessing hazardous materials release risk involved a review of data from the Missouri Environmental Emergency Response Tracking System, the Pipeline and Hazardous Materials Safety Administration, the Missouri Highway Patrol’s Division of Drug and Crime Control, and other information on hazardous materials transport.

Table 3.46. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Moderate – Potential for injuries would typically be highly localized to the release area. Broader public health implications could result.	High
Property	Highly Likely (100%)	Low – Structures are unlikely to be damaged by a hazardous materials release; however, structures affected by a release would require some degree of cleanup and remediation.	High
Environment	Highly Likely (100%)	High – Significant environmental impacts are possible, including air, water, and soil contamination. Air and water contamination could easily spread and have distant impacts.	Moderate

Subject	Probability	Severity	Overall Risk
Operations	Highly Likely (100%)	Low – Critical facilities and infrastructure are unlikely to be affected, but local and state response efforts will be required to manage initial response and oversee remediation efforts.	High
Overall	Highly Likely (100%)	Moderate	High

Vulnerability Assessment

The methodology for assessing hazardous materials release vulnerability involved development of a hypothetical release scenario cost estimate and analysis of past incidents to estimate potential losses.

Table 3.47. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	Individuals who live or work near fixed facilities or transportation routes that hold or carry hazardous materials are most vulnerable to impacts from a release.
Property	Facilities that store or manufacture hazardous materials are vulnerable to impacts from a release.
Environment	Average annual cost of remediation for fixed facility incidents is estimated at $10,309,941.
Operations	Critical facilities and infrastructure involved with remediation, water quality, air quality, and transportation could be impacted by hazardous materials releases.

Consequence Analysis

The overall consequence score for hazardous materials release is 14, which is rated as moderate consequence.

Table 3.48. Consequence Analysis Results

Subject	Consequence Score
Public	2 – Moderate
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	1 – Minimal
Property, Facilities, and Infrastructure	2 – Moderate
Environment	3 – Severe
Economic Condition of Jurisdiction	2 – Moderate
Public Confidence in the Jurisdiction's Governance	2 – Moderate

Mass Transportation

See the Mass Transportation hazard profile in Section 3.3.17 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing mass transportation risk combined quantitative and qualitative approaches. Past event narratives were reviewed to provide a qualitative assessment of the expected impacts from mass transportation. Additionally, data from the Missouri State Highway Patrol Statistical Analysis Center was used to analyze past incidents.

Table 3.49. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Highly Likely (100%)	Moderate – An average of 2,669 commercial crashes resulted in injuries and 126 in death.	High
Property	Highly Likely (100%)	Moderate – An average of 11,024 commercial crashes resulted in property damage. Past mass transportation incidents have resulted in derailed trains, and vehicle accidents that may result in costly damage.	High
Environment	Highly Likely (100%)	Low – Localized impact expected to be severe for incident areas and moderate to light for other areas affected by smoke or HazMat remediation.	Moderate
Operations	Highly Likely (100%)	Moderate – Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services, with length of postponement dependent on incident type and severity.	High
Overall	Highly Likely (100%)	Moderate	High

Vulnerability Assessment

The methodology for assessing mass transportation vulnerability included an estimation of losses, and a review of historical damages. Using the Missouri Department of Transportation's Missouri State Highway System Traffic Crash Statistics as a basis for the number of vehicle crashes and the Federal Highway Administration's costs of a traffic crash, a potential loss estimate was calculated.

Table 3.50. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	An estimated 580 injuries and 7 deaths are estimated to occur form a mass transportation incident, totaling over $38 million in costs.
Property	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to occur in incident areas and moderate to light for other areas affected by remediation.
Operations	Areas with transportation hubs and facilities that experience greater traffic and densities are more vulnerable to mass transportation incidents.

Consequence Analysis

The overall consequence score for mass transportation is 16, which is rated as moderate consequence.

Table 3.51. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	2 – Moderate
Property, Facilities, and Infrastructure	2 – Moderate
Environment	3 – Severe
Economic Condition of Jurisdiction	2 – Moderate
Public Confidence in the Jurisdiction's Governance	2 – Moderate

Nuclear Power Plants

See the Nuclear Power Plants hazard profile in Section 3.3.18 for more detail on overall risk and vulnerability.

Risk Assessment

The methodology for assessing nuclear power plants risk involved a review of data from the Nuclear Regulatory Commission and the Missouri Nuclear Power Plant Accident Plan.

Table 3.52. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Possible (<1%)	Moderate – The primarily risk related to a severe incident at a nuclear power plant is exposure to radiation, which could result in injuries, illness, or death, particularly within the plant and within a 10 mile radius of the plant. Even a less severe event could require widespread evacuations and cause psychological stress and harm.	Low
Property	Possible (<1%)	Moderate – Structures within a 10-mile radius emergency planning zone of a power plant could experience damage or radiological contamination.	Low
Environment	Possible (<1%)	High – Significant environmental impacts could occur if nuclear radiation is released, including contamination of air, water, and soil as well as food sources. These impacts are expected generally within a 50-mile radius ingestion pathway zone.	Moderate
Operations	Possible (<1%)	Moderate – Radiological contamination could severely disrupt normal operations and would require significant response efforts.	Low
Overall	Possible (<1%)	Low to High	Moderate

Vulnerability Assessment

The methodology for assessing nuclear power plants vulnerability involved a review of power plant locations relative to the state's building and critical facilities inventories. Resources on nuclear power plant emergency planning were also reviewed.

Table 3.53. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	Individuals within 50 miles of a nuclear power plant are most vulnerable to direct or indirect radiation from an incident. Those within the 10-mile emergency planning zone are most vulnerable to direct radiation. There are approximately 10,000 people living within 10 miles of a nuclear power plant in Missouri.
Property	Buildings within 10 miles of a nuclear power plant are most vulnerable to contamination and other damages.
Environment	Air and water quality, food sources, native species and habitat are all vulnerable to nuclear power plant incidents. The most vulnerable resources are those within 50 miles of a nuclear power plant.
Operations	There are 46 critical facilities within 10 miles of a nuclear power plant in Missouri. These facilities are valued at $116,346,074.

Consequence Analysis

The overall consequence score for nuclear power plants is 21, which is rated as high consequence.

Table 3.54. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	3 – Severe
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	3 – Severe
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Public Health Emergencies

See the Public Health Emergencies hazard profile in Section 3.3.19 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for assessing public health emergencies risk involved a review of past and current public health emergencies, and an assessment of the EPA's Toxic Release Inventory (TRI) data for Missouri facilities.

Table 3.55. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Possible (<1%)	High – Recent public health emergencies have impacted millions of people across Missouri with tens of thousands of lives lost and millions infected.	Moderate
Property	Possible (<1%)	Low – Property is not at risk.	Low
Environment	Possible (<1%)	Low – Crops and other environmental resources like animals, water sources, and air may be vectors for viruses or bacteria that lead to emergencies. Mitigation measures could impact crop yields, habitats, access to certain resources.	Low
Operations	Possible (<1%)	Moderate – Hospitals and schools have been significantly impacted by past public health emergencies. These facilities have experienced overcrowding, closure, inadequate resources.	Low
Overall	Possible (<1%)	Moderate	Low

Vulnerability Assessment

The methodology for assessing environmental health emergencies vulnerability included a review of historical events noted in past occurrences and a review of the Missouri Department of Natural Resources 2020 Missouri Integrated Water Quality Repot to estimate potential losses.

Table 3.56. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	The entire state is vulnerable to environmental health emergencies, however institutionalized elderly, prison populations, and children, especially un-immunized children, are vulnerable to public health emergencies.
Property	Properties are not vulnerable to physical damage from environmental emergencies.

Subject	Exposure, Annualized Loss, and/or Potential Losses
Environment	Incident may cause denial or delays in the use of some areas. Contaminated crops, waterways, and select animal species may be vectors of harmful bacteria or viruses.
Operations	Water supply infrastructure and personnel require continual and incident-related response to protect clean water supply. Schools, hospitals, and prisons may face increased challenges as they deal with vulnerable populations.

Consequence Analysis

The overall consequence score for public health emergencies is 17, which is rated as moderate consequence.

Table 3.57. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	3 – Severe
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	1 – Minimal
Environment	1 – Minimal
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Special Events

See the Special Events hazard profile in Section 3.3.20 for more detail on overall risk and vulnerability.

Risk Assessment

The methodology for assessing special events risk involved a review of information from the Department of Homeland Security as well as a review of past special events, including events that involved threats to public safety.

Table 3.58. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Possible (<1%)	Moderate – Concerns related to special events include the potential for injuries or deaths as these events may be targets for violence.	Low
Property	Possible (<1%)	Low – Property damage is unlikely but would be highly localized.	Low
Environment	Possible (<1%)	Low – Environmental damage is unlikely.	Low
Operations	Possible (<1%)	High – Special events require significant planning and coordination across multiple departments and agencies. Resources from multiple critical facilities would be required. Key infrastructure could be a target of attack during a special event.	Low
Overall	Possible (<1%)	Low to High	Moderate

Vulnerability Assessment

The methodology for assessing special events vulnerability involved the review of a hypothetical scenario and associated loss estimates and impacts using the Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) tool from Johns Hopkins University.

Table 3.59. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	A hypothetical scenario involving an improvised explosive device near a stadium estimated that a potential 695 deaths and over 7,000 injuries requiring treatment would occur.
Property	A hypothetical scenario involving an improvised explosive device near a stadium estimated that approximately $2,150,000 in damages to vehicles would occur.
Environment	Localized environmental damage could occur depending on the nature of the incident.
Operations	Critical facilities and infrastructure could be targeted. Localized impacts to roads and utilities could occur.

Consequence Analysis

The overall consequence score for special events is 12, which is rated as low consequence.

Table 3.60. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	2 – Moderate
Property, Facilities, and Infrastructure	1 – Minimal
Environment	1 – Minimal
Economic Condition of Jurisdiction	1 – Minimal
Public Confidence in the Jurisdiction's Governance	2 – Moderate

Terrorism

See the Terrorism hazard profile in Section 3.3.21 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for terrorism risk involved a review of past and current public health emergencies, and an assessment of the EPA's Toxic Release Inventory (TRI) data for Missouri facilities.

Table 3.61. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Possible (<1%)	Moderate – Impacts to people could include a few people in an isolated incident to hundreds and even of thousands of people impacted or injured.	Moderate
Property	Possible (<1%)	High – Past occurrences have resulted in significant impacts to property. Buildings can be directly targeted or damaged during an incident or response.	Moderate
Environment	Possible (<1%)	Low – Crops not likely to impacted, other environmental resources could be the target of an incident (waterways) or may be impacted by debris, response efforts.	Low

Subject	Probability	Severity	Overall Risk
Operations	Possible (<1%)	Moderate – Electrical utilities, and other infrastructure may be the target of an incident and face substantial impacts. Police, EMT, and hospitals likely face increased requests for services.	Moderate
Overall	Possible (<1%)	Moderate	Moderate

Vulnerability Assessment

The methodology for assessing environmental health emergencies vulnerability included a review of historical events noted in past occurrences. Additionally, loss estimates were assessed by using hypothetical scenarios developed by Johns Hopkins called Electronic Mass Casualty Assessment and `Planning Scenarios (EMCAPS) which utilizes scenarios put together by the Department of Homeland Security. Potential losses for this hazard include all infrastructure, critical facilities, humans, and animals.

Table 3.62. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	People that live in areas with greater population densities or attend large gatherings are more vulnerable to attacks.
Property	Large gathering venues, important buildings, or properties hosting an event may face increased vulnerability of attacks. Potential losses would include cost of repair or replacement of damaged facilities
Environment	Environmental resources (parks, waterbodies), may be vulnerable to debris or secondary damage if in close proximity to attacked area.
Operations	Important facilities that provide critical services may be a target for attacks (electrical utilities, hospitals, transportation corridors). Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.

Consequence Analysis

The overall consequence score for terrorism is 21, which is rated as high consequence.

Table 3.63. Consequence Analysis Results

Subject	Consequence Score
Public	3 – Severe
Responders	3 – Severe
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	3 – Severe
Economic Condition of Jurisdiction	3 – Severe
Public Confidence in the Jurisdiction's Governance	3 – Severe

Utilities (Interruptions & System Failures)

See the Utilities hazard profile in Section 3.3.22 for more detail on the overall risk and vulnerability assessments, including data sources, information on past occurrences, and loss estimates.

Risk Assessment

The methodology for utilities risk involved a review of past and current public health emergencies, and an assessment of the EPA's Toxic Release Inventory (TRI) data for Missouri facilities.

Table 3.64. Risk Assessment Results

Subject	Probability	Severity	Overall Risk
Public	Possible (<1%)	Low – People in localized areas may experience temporary power outages or water supply challenges for a few hours or longer periods in severe cases (days). Outages may interrupt daily activities.	Low
Property	Possible (<1%)	Low – Physical property is unlikely to be affected. However, disruptions may impact the utility of certain properties. Business, office space, and restaurants may suffer financial impacts from interrupted internet, electrical, or water supply.	Low
Environment	Possible (<1%)	Low – Water supply and electrical interruptions may impact crop production.	Low
Operations	Possible (<1%)	Moderate – In many cases, utility interruptions are isolated events but, in some instances, utility outages and interruptions can impact a larger area and be for a prolonged period.	Moderate
Overall	Possible (<1%)	Low	Low

Vulnerability Assessment

The methodology for assessing utilities vulnerability included a review of past occurrences. Additionally, loss estimates were assessed using FEMA's BCA Reference Guide Loss of Use Estimates. The loss of use estimates used Census data to estimate the population served and loss of use cost per person per day.

Table 3.65. Vulnerability Assessment Results

Subject	Exposure, Annualized Loss, and/or Potential Losses
Public	In rural areas, the typical loss of use may be for a larger percentage of the population and for longer periods of time during weather extremes. People with medical issues or reliance on particular medical equipment may be vulnerable to utility interruptions.
Property	Electrical blackouts and power surges can damage high tech equipment but generally do not cause structural damage. Secondary effects of infrastructure failure could include burst water pipes in homes without electricity during winter storms and damage to equipment due to power surges
Environment	Environmental assets are not vulnerable to utility disruption.
Operations	Potential losses include the cost of repair or replacement of damaged facilities. Power and telephone lines are the most vulnerable infrastructure asset; but water supply, wastewater facilities and communications towers are also vulnerable. Estimates for loss of service are: electricity ($148/person/day), potable water ($105/person/day), and wastewater ($49/person/day).

Consequence Analysis

The overall consequence score for Utilities is 18, which is rated as high consequence.

Table 3.66. Consequence Analysis Results

Subject	Consequence Score
Public	2 – Moderate
Responders	2 – Moderate
Continuity of Operations including Continued Delivery of Services	3 – Severe
Property, Facilities, and Infrastructure	3 – Severe
Environment	2 – Moderate
Economic Condition of Jurisdiction	3 – Severe

Subject	Consequence Score
Public Confidence in the Jurisdiction's Governance	3 – Severe

Appendix D: Funding Sources

Program/Activity	Type of Assistance	Agency and Contact
General Emergency Management Grants, Loans, and Technical Assistance		
Hazard Mitigation Grant Program	Post-disaster project grants to implement measures that will permanently reduce or eliminate future damages and losses from natural hazards through safer building practices and by improving existing structures and supporting infrastructure.	FEMA Region VII (816) 283-7061 https://www.fema.gov/region-vii-ia-ks-mo-ne Hazard Mitigation Assistance Grants | FEMA.gov SEMA (573) 526-9100 http://sema.dps.mo.gov/
Building Resilient Infrastructure and Community (BRIC) Program	Competitive grant program which supports state, local, tribal and territorial government as they implement hazard mitigation projects to reduce the risks from disasters and natural hazards. BRIC replaced FEMA's legacy Pre-Disaster Mitigation program for new pre-disaster awards	FEMA Region VII (816) 283-7061 https://www.fema.gov/region-vii-ia-ks-mo-ne Hazard Mitigation Assistance Grants | FEMA.gov SEMA (573) 526-9100 http://sema.dps.mo.gov/
Pre-Disaster Mitigation Program	Competitive project grants for cost-effective hazard mitigation activities that are part of a comprehensive mitigation program and that reduce injuries, loss of life, and damage and destruction of property.	FEMA Region VII (816) 283-7061 https://www.fema.gov/region-vii-ia-ks-mo-ne Hazard Mitigation Assistance Grants | FEMA.gov SEMA (573) 526-9100 http://sema.dps.mo.gov/
Disaster Mitigation Planning and Technical Assistance	Technical and planning assistance for capacity building and mitigation project activities focusing on creating disaster resistant jobs and workplaces.	Economic Development Administration (202) 482-2000 (202) 482-5081 EDA And Disaster Recovery | U.S. Economic Development Administration SEMA (573) 526-9100 https://sema.dps.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
Emergency Management/Mitigation Training	Training in disaster mitigation, preparedness, and planning.	FEMA NFIP and Mitigation (816) 283-7002 http://training.fema.gov/ SEMA (573) 526-9100 https://sema.dps.mo.gov/about/prepardness.php
Post-disaster Economic Recovery Grants and Assistance	Grant funding to assist with the long-term economic recovery of communities, industries, and firms adversely impacted by disasters.	Economic Development Administration (202) 482-2000 (202) 482-5081 Funding Opportunities | U.S. Economic Development Administration (eda.gov) Missouri Department of Economic Development Community Development Block Grant Program (573) 751-3600 http://ded.mo.gov/
Physical Disaster Loans and Economic Injury Disaster Loans	Disaster loans to nonfarm, private sector owners of disaster damaged property for uninsured losses. Loans can be increased by up to 20 percent for mitigation purposes.	Small Business Administration (800) 659-2955 www.sba.gov/services/disasterassistance
Disaster Grants—Public Assistance	Grants for the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain private nonprofit organizations. Mitigation funding is available for work related to damaged components of eligible buildings/structures.	FEMA Region VII (816) 283-7061 Assistance for Governments and Private Non-Profits After a Disaster | FEMA.gov SEMA (573) 526-9100 http://sema.dps.mo.gov/
Public Infrastructure Grants	• Public Facilities: Grants for public improvement of facilities except work on general public office buildings, includes water facilities, flood and drainage facilities, fire protection facilities/equipment, and bridges. • Neighborhoods: Grants for housing and some public	Missouri Department of Economic Development Community Development Block Grant Program (573) 751-3600 http://ded.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
Public Infrastructure Grants (continued)	facilities. • Infrastructure: Grants for storm sewers, drainage, and land acquisitions. • Downtown Revitalization: Grants for improving public infrastructure and facilities in a central business district. • Emergencies: Grants for public improvement or facilities except work on general public office buildings, includes water facilities and solid waste disposal facilities.	
Community Development Block Grants State's Program	Grants to states to develop viable communities (e.g., housing, a suitable living environment, expanded economic opportunities) in non-entitled areas, for low- and moderate-income persons.	U.S. Department of Housing and Urban Development Community Planning and Development (202) 708-1112 https://www.hud.gov/program_offices/comm_planning HUD Kansas City Regional Office (western half of MO) (913) 551-5644 Contact HUD: Kansas | HUD.gov / U.S. Department of Housing and Urban Development (HUD) HUD St. Louis Field Office (eastern half of MO) (314) 4175400 Contact HUD: Missouri | HUD.gov / U.S. Department of Housing and Urban Development (HUD) Missouri Department of Economic Development (573) 522-4173 http://ded.mo.gov/
Community Development Block Grants/Entitlement Grants	Grants to entitled cities and urban counties to develop viable communities (e.g., decent housing, suitable living environments, expanded economic opportunities), principally for low- and moderate-income persons.	U.S. Department of Housing and Urban Development Community Planning and Development (202) 708-1112 https://www.hud.gov/program_offices/comm_planning HUD Kansas City Regional Office (western half of MO) (913) 551-5644 Contact HUD: Kansas | HUD.gov / U.S. Department of

Program/Activity	Type of Assistance	Agency and Contact
Community Development Block Grants/Entitlement Grants (continued)		Housing and Urban Development (HUD) HUD St. Louis Field Office (eastern half of MO) (314) 4175400 Contact HUD: Missouri | HUD.gov / U.S. Department of Housing and Urban Development (HUD) Missouri Department of Economic Development (573) 522-4173 http://ded.mo.gov/
Disaster Recovery Assistance	Critical housing and community development resources to aid disaster recovery (including mitigation).	U.S. Department of Housing and Urban Development Community Planning and Development (202) 708-1112 https://www.hud.gov/program_offices/comm_planning HUD Kansas City Regional Office (western half of MO) (913) 551-5644 Contact HUD: Kansas | HUD.gov / U.S. Department of Housing and Urban Development (HUD) HUD St. Louis Field Office (eastern half of MO) (314) 4175400 Contact HUD: Missouri | HUD.gov / U.S. Department of Housing and Urban Development (HUD) Missouri Department of Economic Development (573) 522-4173 http://ded.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
Public Housing Capital Fund Emergency/Natural Disaster Funding	Funding to public housing agencies that confront an emergency situation or a natural disaster.	U.S. Department of Housing and Urban Development Office of Capital Improvements (202) 402-2488 https://www.hud.gov/program_offices/public_indian_housing/programs/ph/capfund Missouri Department of Economic Development Missouri Housing Development Commission (816) 759-6600 www.mhdc.com/
Indian Housing Assistance (Housing Improvement Program)	Project grants and technical assistance to eliminate substantially sub-standard Indian owned and inhabited housing.	Bureau of Indian Affairs Office of Indian Services Division of Human Services (202) 208-5116 https://www.bia.gov/bia/ois/dhs/housing-improvement-program
Single Family Housing Direct Home Loans (Section 502 Direct Loan Program)	This program assists low- and very-low-income applicants obtain decent, safe and sanitary housing in eligible rural areas by providing payment assistance to increase an applicant's repayment ability. Payment assistance is a type of subsidy that reduces the mortgage payment for a short time. The amount of assistance is determined by the adjusted family income.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 (direct loans) Single Family Housing Repair Loans & Grants | Rural Development (usda.gov) USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Single Family Housing Repair Loans and Grants (Section 504 Rural Housing Loans and Grants)	Repair loans, grants, and technical assistance for very low-income homeowners living in rural areas to repair their homes and remove health and safety hazards.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 (direct loans) (202) 720-1452 (guaranteed loans) Single Family Housing Repair Loans & Grants | Rural Development (usda.gov) USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo

Program/Activity	Type of Assistance	Agency and Contact
Guaranteed Single Family Housing Loans (Section 502 Rural Housing Loans)	Loans, loan guarantees, and technical assistance to help very low, low-income, and moderate-income households in rural areas buy, build, or improve permanent residences.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 (direct loans) Single Family Housing Guaranteed Loan Program | Rural Development (usda.gov) USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Farm Ownership Loans	Direct loans, guaranteed/insured loans, and technical assistance to farmers to develop, construct, improve, or repair farm homes, farms, and service buildings and to make other necessary improvements.	U.S. Department of Agriculture Farm Service Agency https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/ Missouri Department of Agriculture (573) 751-4211 http://mda.mo.gov/
HOME Investment Partnerships Program	Grants to states, local government, and consortia for permanent and transitional housing (including support for property acquisition, improvements, demolition, and relocation) for very low and low-income persons.	U.S. Department of Housing and Urban Development (HUD) Community Planning and Development Affordable Housing Programs HOME Investment Partnership Programs (202) 708-1112 HOME Investment Partnerships Program | HUD.gov / U.S. Department of Housing and Urban Development (HUD) Missouri Department of Economic Development Missouri Housing Development Commission (816) 759-6600 www.mhdc.com
Rural Development Assistance—Utilities	Direct and guaranteed rural economic loans and business enterprise grants to address utility issues and development needs.	U.S. Department of Agriculture (USDA) Rural Development Utilities Program (202) 720-9540 https://www.rd.usda.gov/about-rd/agencies/rural-utilities-

Program/Activity	Type of Assistance	Agency and Contact
Rural Development Assistance—Utilities (continued)		service USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Rural Development Assistance—Community Facility Direct Loans/Grants	Grants, direct and guaranteed loans, and technical assistance to construct, enlarge, or improve community facilities for healthcare, public safety, and public services in primarily low-income rural areas.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 (direct loans) (202) 720-1452 (guaranteed loans) https://www.usda.gov/topics/rural/housing-assistance USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Volunteer Fire Assistance (VFA) Program, formerly known as the Rural Community Fire Protection Program	Grants for rural fire projects or assistance, including dry fire hydrants, equipment, and training.	Missouri Department of Conservation 573-522-4115, ext. 3113 Fire Department Assistance Programs | Missouri Department of Conservation (mo.gov)
Community Development Block Grant—Section 108 Loan Guarantees	Loan guarantees to public entities for economic development, housing rehabilitation, public facilities, and large-scale physical development projects (including mitigation measures).	U.S. Department of Housing and Urban Development Community Planning and Development/Section 108 (202) 708-1871 Section 108 | HUD.gov / U.S. Department of Housing and Urban Development (HUD) HUD Kansas City Regional Office (western half of MO) (913) 551-5644 Contact HUD: Kansas | HUD.gov / U.S. Department of Housing and Urban Development (HUD) HUD St. Louis Field Office (eastern half of MO) (314) 4175400 https://www.hud.gov/states/missouri/working/missourioffices

Program/Activity	Type of Assistance	Agency and Contact
Community Development Block Grant—Section 108 Loan Guarantees (continued)		Missouri Department of Economic Development Missouri Housing Development Commission (816) 759-6600 www.mhdc.com/
Homeland Security Grant Program	Grants to enhance the ability of states, territories, and urban areas to prepare for, prevent, and respond to terrorist attacks and other major disasters. Includes State Homeland Security Program, Urban Areas Security Initiative, Law Enforcement Terrorism Prevention Program, Metropolitan Medical Response System, and Citizen Corps Program grant programs.	FEMA Grants Management 816-283-7084 Homeland Security Grant Program | FEMA.gov
Critical Infrastructure Protection	Grants to strengthen the nation's ability to protect critical infrastructure facilities and systems. Includes Transit Security Grant Program, Port Security Grant Program, Intercity Bus Security Grant Program, Trucking Security Program, and Buffer Zone Protection Program grant programs.	US Fire Administration Grants Management 816-283-7084 https://www.usfa.fema.gov/a-z/critical-infrastructure-protection.html
Assistance to Firefighters Grant Program	Grants to local fire departments to protect citizens and firefighters against the effects of fire and fire-related incidents.	FEMA U.S. Fire Administration (800) 238-3358 Fire service grants and funding (fema.gov) FEMA Region VII (816) 283-7951 Region 7 | FEMA.gov
Fire Prevention and Safety Grant Program	Grants for projects that enhance the safety of the public and firefighters from fire and related hazards. The primary goal is to target high-risk populations and mitigate high incidences of death and injury.	FEMA U.S. Fire Administration (800) 238-3358 Fire Prevention and Safety | FEMA.gov FEMA Region VII (816) 283-7951 Region 7 | FEMA.gov

Program/Activity	Type of Assistance	Agency and Contact
Fire Management Assistance Grant Program	Grants for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands, which threaten such destruction as would constitute a major disaster.	FEMA Region VII (816) 283-7951 https://www.fema.gov/assistance/public/fire-management-assistance
Hazardous Materials Emergency Preparedness Program	Project grants and technical assistance to enhance hazardous materials emergency planning and training.	U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (202) 366-4433 https://www.phmsa.dot.gov/about-phmsa/working-phmsa/grants
Floods/Flood Control Grants, Loans, and Technical Assistance		
Flood Mitigation Assistance Program	Planning, project, and technical assistance grants to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program.	FEMA (816) 283-7061 https://www.fema.gov/flood-mitigation-assistance-grant-program SEMA (573) 526-9375 http://sema.dps.mo.gov/
National Flood Insurance Program	Flood insurance to residents of communities that adopt and enforce minimum floodplain management requirements.	FEMA Region VII NFIP and Mitigation (816) 283-7061 https://www.fema.gov/national-flood-insurance-program SEMA (573) 526-9129 https://sema.dps.mo.gov/programs/floodplain/
Flood Control Planning Assistance	Technical and planning assistance for the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
Flood Control Planning Assistance (continued)		Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Nonstructural Alternatives to Structural Rehabilitation of Damaged Flood Control Works	Direct planning and construction grants for nonstructural alternatives to the structural rehabilitation of flood control works damaged in floods or coastal storms.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551

Program/Activity	Type of Assistance	Agency and Contact
		www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
Floodplain Management Services	Technical and planning assistance at the local, regional, or national level needed to support effective floodplain management.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Land Protection	Technical assistance for run-off retardation and soil erosion prevention to reduce hazards to life and property.	U.S. Department of Agriculture Natural Resources Conservation Service (202) 720-7246 https://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/

Program/Activity	Type of Assistance	Agency and Contact
Dam Safety Programs	Technical assistance, training, and grants to help improve state dam safety programs.	FEMA Dam Safety (816) 283-7061 https://www.fema.gov/dam-safety Missouri Department of Natural Resources Water Resources Center Dam and Reservoir Safety Program (573) 368-2100 Dam and Reservoir Safety | Missouri Department of Natural Resources (mo.gov)
Earthquake Grants, Loans, and Technical Assistance		
National Earthquake Hazards Reduction Program and Other Earthquake Hazards Reduction Programs	Technical and planning assistance for activities associated with earthquake hazards mitigation.	FEMA (816) 283-7002 Earthquake Risk | FEMA.gov SEMA (573) 526-9100 https://sema.dps.mo.gov/programs/earthquake.php
Geological Survey Program	Acquire, maintain, and manage basic geological data and identify and evaluate geological hazards. The Geological Survey Program assists Missourians, industry, and government in the wise use of Missouri's minerals, land, and water resources.	Missouri Department of Natural Resources Geological Survey Program (573) 368-2100 Missouri Geological Survey | Missouri Department of Natural Resources (mo.gov)
All-Hazard Mapping Grants, Loans, and Technical Assistance		
National Flood Insurance Program: Flood Mapping	Flood insurance rate maps and floodplain management maps for all NFIP communities.	FEMA National Flood Insurance Program (816) 283-7002 https://www.fema.gov/national-flood-insurance-program SEMA (573) 526-9375 http://sema.dps.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
National Digital Orthophoto Programs	Develops topographic quadrangles for use in mapping of flood and other hazards.	U.S. Geological Survey National Map https://www.usgs.gov/programs/national-geospatial-program/national-map SEMA (573) 526-9100 https://sema.dps.mo.gov/maps_and_disasters/
National Streamflow Information Program	Operation of a network of over 7,000 stream gaging stations that provide data on river flood characteristics.	U.S. Geological Survey Office of Surface Water (703) 648-5301 https://pubs.usgs.gov/gip/70/
Mapping Standards Support	Expertise in mapping and digital data standards to support the National Flood Insurance Program.	U.S. Geological Survey National Map https://www.usgs.gov/programs/national-geospatial-program/national-map SEMA (573) 526-9100 https://sema.dps.mo.gov/maps_and_disasters/
Earthquake Hazards Program	Seismic hazard maps.	U.S. Geological Survey (650) 329-4668 https://www.usgs.gov/programs/earthquake-hazards/maps Missouri Department of Natural Resources Geological Survey Program (573) 368-2100 https://sema.dps.mo.gov/programs/earthquake.php SEMA (573) 526-9100 https://sema.dps.mo.gov/maps_and_disasters/

Program/Activity	Type of Assistance	Agency and Contact
Cooperating Technical Partners	Technical assistance, training, and data to support flood hazard data development activities.	FEMA Region VII (816) 283-7073 https://www.fema.gov/cooperating-technical-partners-program-0
Risk Mapping, Assessment and Planning (Risk MAP)	Provides funding to supplement, not supplant, ongoing flood hazard mapping management efforts by local, regional, and State agencies.	FEMA Region VII Map Modernization (816) 283-7009 Risk Mapping, Assessment and Planning (Risk MAP) | FEMA.gov
Community Assistance Program State Support Services Element (CAP-SSSE)	Provides funding to states to provide technical assistance to communities in the National Flood Insurance Program (NFIP) and to evaluate community performance in implementing NFIP floodplain management activities.	FEMA Region VII NFIP and Mitigation (800) 621-3362 https://www.fema.gov/community-assistance-program-state-support-services-element SEMA (573) 526-9100 http://sema.dps.mo.gov/
Geospatial Platform	The Geospatial Platform is a cross-agency collaborative effort and Shared Service that embodies the principles and spirit of Open Government, emphasizing government-to-citizen communication, accountability, and transparency.	Geospatial Platform GeoPlatform.gov | Making Federal GeoData Findable, Accessible, Interoperable, and Reusable
Missouri Spatial Data Information Service	Provides GIS and census data about the State of Missouri.	Missouri Spatial Data Information Service University of Missouri–Columbia (573) 882-6606 http://msdis.missouri.edu/
Center for Agriculture, Resource, and Environmental Systems	Provides maps and research findings to help better address resource, environmental, and socioeconomic issues.	Center for Agriculture, Resource, and Environmental Systems University of Missouri–Columbia http://www.cares.missouri.edu/

Program/Activity	Type of Assistance	Agency and Contact
Ancillary Flood and Natural Resource Projects Grants, Loans, and Assistance		
Natural Resources Financial Assistance	Financial and technical assistance programs available to Missouri communities.	Missouri Department of Natural Resources (800) 361-4827 contact@dnr.mo.gov Helping Missouri Communities Thrive: Financial Assistance Opportunities - PUB3044 | Missouri Department of Natural Resources (mo.gov)
Wastewater Financial Opportunities	The Financial Assistance Center offers funding for wastewater infrastructure planning and construction through a variety of funding programs.	Missouri Department of Natural Resources Financial Assistance Center (573) 751-1192 https://dnr.mo.gov/water/business-industry-other-entities/financial-opportunities/financial-assistance-center/wastewater
Natural Resources Financial Assistance	• Agriculture Loan Program—Loans to individual farmers for animal waste treatment facilities. • Cooperative Remonumentation Program—Contract with county commissions to remonument corners of the U.S. Public Land Survey System. • County Boundary Resurvey Program—Contract with county commissions to remonument county boundary lines where location of line is indefinite. • Geodetic Control Densification Project—Contract with county, city government, and municipal utilities to establish horizontal and vertical control monuments used for mapping and the development of land survey information system.	Missouri Department of Agriculture http://agriculture.mo.gov/abd/financial/ (573) 751-4762 State Surveyor http://agriculture.mo.gov/weights/landsurvey/ (573) 368-2300
	• Hazardous Substance Emergency Relief Loan Fund—Loans to political subdivisions or volunteer fire protection associations for reimbursement of actual costs incurred in responding to a hazardous substance emergency.	Missouri Department of Natural Resources Environmental Services Program (573) 526-3315; (800) 361-47827 Hazardous Substance Emergency Response Cost Recovery Information - PUB2095 | Missouri Department of Natural Resources (mo.gov)

Program/Activity	Type of Assistance	Agency and Contact
Natural Resources Financial Assistance (continued)	• Local Government Reimbursement Program—Local communities can be reimbursed up to $25,000 for costs incurred in responding to a hazardous substance emergency. • Underground Storage Tank Financial Responsibility - In Missouri, petroleum UST owners and operators are required to have funds set aside to pay for the cleanup and other damages that may occur from a release from their UST systems. This requirement is known as financial responsibility. • Private Activity Bond Financing—Issuance of tax-exempt and taxable revenue bonds for private and public companies for facilities and improvements with environmental and energy resource impacts.	U.S. Environmental Protection Agency Local Governments Reimbursement (800) 431-9209 https://www.epa.gov/emergency-response/local-governments-reimbursement-program Missouri Department of Natural Resources Hazardous Waste Management Program Tanks Compliance and Technology Unit (573) 751-3176 https://dnr.mo.gov/waste-recycling/business-industry/financial-assurance-responsibilities/underground-storage-tank Missouri Department of Natural Resources Environmental Improvement and Energy Resources Authority (573) 751-4919 eiera@dnr.mo.gov Private Activity Bonds - Environmental Improvement and Energy Resources Authority (mo.gov)
Environmental Quality Incentives Program	Technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) 202) 720-4527 Apply for Environmental Quality Incentives Program (EQIP) | Natural Resources Conservation Service (usda.gov) NRCS District Office—Columbia, MO (573) 876-0909 Missouri State Office | Natural Resources Conservation Service (usda.gov) Missouri Department of Natural Resources Soil and Water Conservation Program (573) 751-4932 https://dnr.mo.gov/env/swcp/

Program/Activity	Type of Assistance	Agency and Contact
Nonpoint Source Implementation Grants (Clean Water Act Section 319 Grants)	Grants to states to implement nonpoint source programs, including support for nonstructural watershed resource restoration activities.	U.S. Environmental Protection Agency Region VII Water, Wetlands, and Pesticides Division (913) 551-7003 https://www.cfda.gov/index?s=program&mode=list&tab=list Missouri Department of Natural Resources Non-Point Source Control Branch (573) 751-4932 Nonpoint Source Implementation Grant Application MO 780-1896 | Missouri Department of Natural Resources
Capitalization Grants for Clean Water State Revolving Funds	Loans to fund water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management.	U.S. Environmental Protection Agency Region VII Water, Wetlands, and Pesticides Division (913) 551-7003 https://www.epa.gov/cwsrf
National Wetland Program Development Grants	Grants to build capacity to protect, manage, and restore wetlands.	U.S. Environmental Protection Agency Region VII Water, Wetlands, and Pesticides Division (913) 551-7003 https://www.epa.gov/wetlands/wetland-program-development-grants-and-epa-wetlands-grant-coordinators Missouri Department of Natural Resources Geological Survey Program (573) 368-2100 https://dnr.mo.gov/geology/wrc/
Watershed Protection and Flood Prevention Program	Technical assistance for designing and installing watershed works of improvement and financial assistance for cost-sharing of measures for watershed protection, flood prevention, agricultural water management, sedimentation control, etc., in small watersheds under 250,000 acres.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division (202) 720-7246 Landscape Conservation Initiatives | Natural Resources Conservation Service (usda.gov) NRCS District Office—Columbia, MO (573) 876-0901

Program/Activity	Type of Assistance	Agency and Contact
Watershed Protection and Flood Prevention Program (continued)		Missouri Department of Natural Resources Soil and Water Conservation Program (573) 751-4932 https://dnr.mo.gov/env/swcp/
Soil and Water Conservation Program	Technical assistance to the general public in planning and applying natural resource conservation practices, systems, and treatment; and furnishing technical natural resource conservation information to State and local governments.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division (202) 720-7246 Landscape Conservation Initiatives | Natural Resources Conservation Service (usda.gov) NRCS District Office—Columbia, MO (573) 876-0901 Missouri Department of Natural Resources Soil and Water Conservation Program (573) 751-4932 https://dnr.mo.gov/env/swcp/
Landscape Conservation Initiatives	NRCS uses Landscape Conservation Initiatives to accelerate the benefits of voluntary conservation programs, such as cleaner water and air, healthier soil and enhanced wildlife habitat.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) (202) 690-4979 Landscape Conservation Initiatives | Natural Resources Conservation Service (usda.gov)
Project Modifications for Improvement of the Environment	Provides for ecosystem restoration by modifying structures and/or operations or water resources projects constructed by the U.S. Army Corps of Engineers or restoring areas where a Corps project contributed to the degradation of an area.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000

Program/Activity	Type of Assistance	Agency and Contact
Project Modifications for Improvement of the Environment (continued)		www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Aquatic Ecosystem Restoration	Direct support for carrying out aquatic ecosystem restoration projects that will improve the quality of the environment.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
Aquatic Ecosystem Restoration (continued)		Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Planning Assistance to States (Water Resources Development Act)	Financial and technical assistance to prepare comprehensive plans for the development, use, and conservation of water and related land resources.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
Beneficial Uses of Dredged Materials	Direct assistance for projects that protect, restore, and create aquatic and ecologically-related habitats, including wetlands, in connection with dredging an authorized federal navigation project.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
North American Wetland Conservation Act (NAWCA) Grants	Matching grants for projects that provide long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats in the United States.	U.S. Fish and Wildlife Service Division of Bird Habitat Conservation (703) 358-1784 https://www.fws.gov/service/north-american-wetlands-conservation-act-nawca-grants-us-standard

Program/Activity	Type of Assistance	Agency and Contact
Soil Survey	Maintains soil surveys of counties or other areas to assist with farming, conservation, mitigation or related purposes.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Soil Science and Resource Assessment 202-720-7246 http://soils.usda.gov/survey/ NRCS District Office—Columbia, MO (573) 876-0901
Land Acquisition	Acquires or purchases easements on high-quality lands and waters for inclusion into the National Wildlife Refuge System.	U.S. Fish and Wildlife Service Division of Realty (703) 358-1713 Land Acquisition and Realty | U.S. Fish & Wildlife Service (fws.gov)
Transfers of Inventory Farm Properties to Federal and State Agencies for Conservation Purposes	Transfers title of certain inventory farm properties owned by the Farm Service Agency to federal and state agencies for conservation purposes (including the restoration of wetlands and floodplain areas to reduce future flood potential).	U.S. Department of Agriculture Farm Loan Programs https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/
Disposal of Federal Surplus Real Property for Parks, Recreation, and Historic Monuments	Identifies, assesses, and transfers available federal real property for acquisition for state and local parks and recreation, such as open space.	National Park Service (NPS) (402) 661-1928 https://www.nps.gov/orgs/1246/index.htm NPS—Northeast/Midwest Regions (402)-661-1601 https://www.nps.gov/orgs/1671/index.htm
Recreation and Parks Grants	Grants available to cities, counties, and school districts for outdoor recreation facilities and land acquisition.	Missouri Department of Natural Resources Division of State Parks (573) 751-0848 https://mostateparks.com/page/55065/outdoor-recreation-grants
Partners for Fish and Wildlife	Financial and technical assistance to private landowners interested in restoring or otherwise improving native habitats for fish and wildlife on their lands.	U.S. Fish and Wildlife Service Branch of Habitat Restoration (703) 358-2201 Partners for Fish and Wildlife | U.S. Fish & Wildlife Service (fws.gov)
Tree Planting Program	Use native trees and shrubs to improve wildlife habitat and conserve soil and water on your land. Order seedlings from Missouri's state forest nursery, and browse planting tips..	Missouri Department of Conservation (573) 751-4115 https://mdc.mo.gov/trees-plants/tree-seedlings

Program/Activity	Type of Assistance	Agency and Contact
Conservation Contracts	Debt reduction for delinquent and nondelinquent borrowers in exchange for conservation contracts placed on environmentally sensitive real property that secures Farm Service Agency loans.	U.S. Department of Agriculture Farm Load Programs https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/
Historic Preservation Fund Grants	Federal matching grants, known as the Historic Preservation Fund to assist in carrying out historic preservation activities. Sponsored by the National Park Service.	Missouri Department of Natural Resources Division of State Parks (573) 751-7858 Historic Preservation Fund Grants | Missouri State Parks (mostateparks.com)
The Foundation Directory	Annual source of information about grants and loans from federal and private sources. Available for a fee.	The Foundation Directory (800) 478-4661 https://fconline.foundationcenter.org/
Federal Assistance Monitor	Published by CD Publications. Semi-monthly report on federal and private grants. Available for a fee.	CD Publications (855) 237-1396 https://www.cdpublications.com/fam/
SAM.gov Assistance Listings (formerly Catalog of Federal Domestic Assistance)	Database of all federal programs available to State and local governments; federally recognized Indian tribal governments; domestic public, quasi-public, and private profit and nonprofit organizations and institutions; specialized groups; and individuals.	Assistance Listings System for Award Management (SAM.gov) https://www.cfda.gov/
Basic and Applied Research/Development		
Decision, Risk, and Management Sciences	Funding for research directed at increasing the understanding and effectiveness of decision making by individuals, groups, organizations, and society.	National Science Foundation Decision, Risk and Management Services (DRMS) (703) 292-7263 https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5423
Science, Technology, and Society	Funding for research that examines questions that arise in the interactions of engineering, science, technology, and society.	National Science Foundation Science, Technology, and Society (STS) 703) 292-7283 https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5324

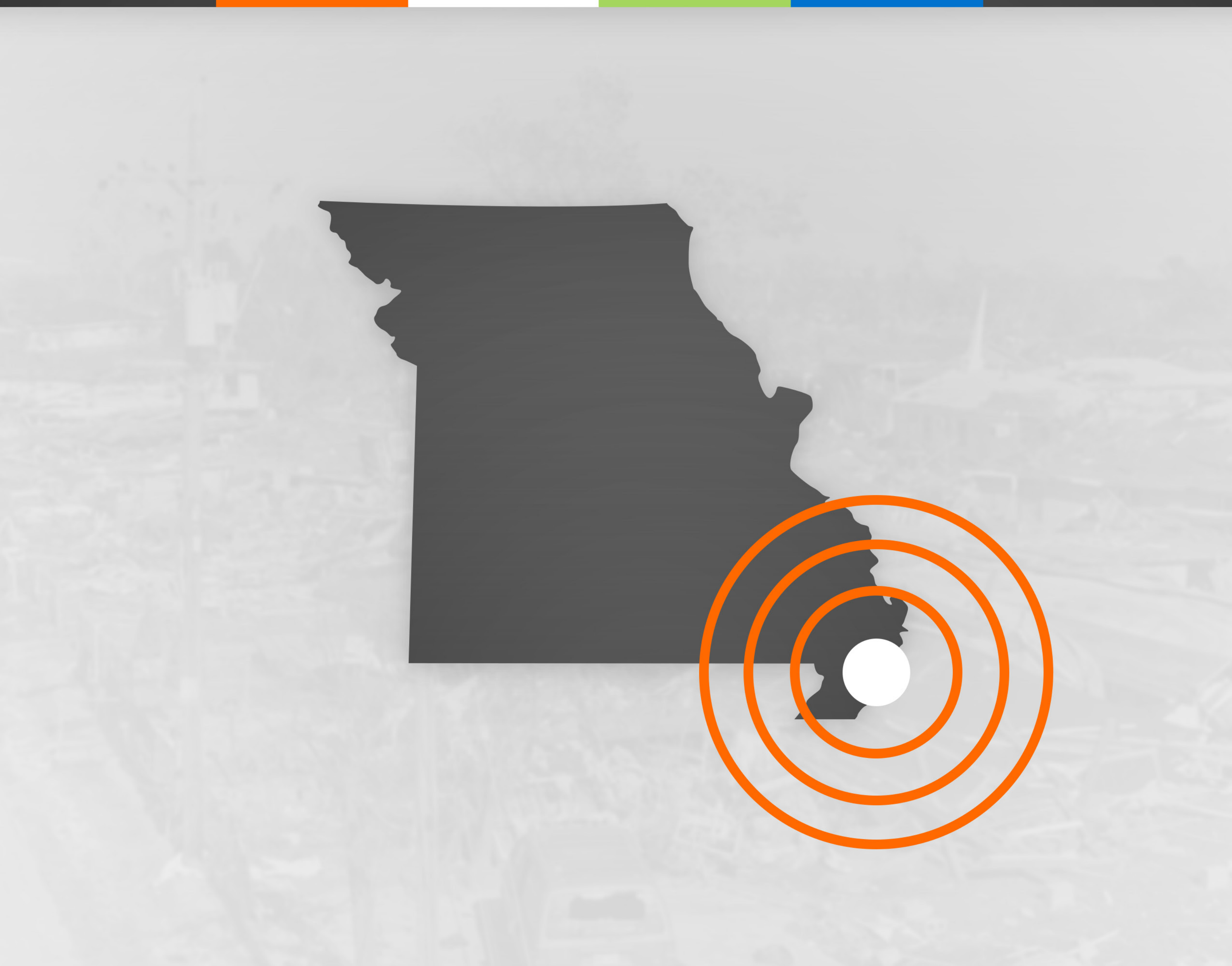
Program/Activity	Type of Assistance	Agency and Contact
National Earthquake Hazards Reduction Program	Funding for research to mitigate earthquake losses by providing earth science data and assessments essential for land use planning, engineering design, and emergency preparedness decisions.	FEMA National Earthquake Hazards Reduction Program (816) 283-7061 https://www.fema.gov/national-earthquake-hazards-reduction-program
Structural Systems and Hazards Mitigation of Structures	Funding for research on new technologies for improving the behavior and response of structural systems subject to natural hazards.	National Science Foundation Directorate for Engineering Division of Civil, Mechanical, and Manufacturing Innovation (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Environmental Technology	Funding for research to develop and test new technologies in the field of environmental engineering emphasizing principles underlying pollution avoidance as well as pollution treatment and remediation.	National Science Foundation Directorate for Engineering Division of Chemical, Bioengineering, Environmental, and Transport Systems (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Infrastructure Management and Hazard Response	Funding for research on multidisciplinary issues concerning the impact of natural, technological, and manmade hazards upon critical infrastructure systems and society.	National Science Foundation Directorate for Engineering Division of Civil, Mechanical, and Manufacturing Innovation (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Environmental Sustainability	Funding for research with the goal of promoting sustainable engineered systems that support human well-being and that also are compatible with sustaining natural (environmental) systems, which provide ecological services vital for human survival.	National Science Foundation Directorate for Engineering Division of Chemical, Bioengineering, Environmental, and Transport Systems (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Behavioral and Social Research on Disasters and Health	Funding for research in the behavioral and social sciences on the consequences of natural and man-made disasters for the health of children, the elderly, and vulnerable groups, with an ultimate goal of preventing or mitigating harmful consequences.	National Institutes of Health (866) 504-9552 https://grants.nih.gov/funding/index.htm

Program/Activity	Type of Assistance	Agency and Contact
Other Planning Resources: Demographics, Societal Data, and Transportation, Agricultural, Industrial, and Economic Statistics		
Demographics, Societal Statistics and Economic Statistics	Free planning information concerning jobs, business and economic statistics, population and housing statistics, and help with census products (i.e., statistics, maps, reports, etc.). Note: For statistics regarding clean water, wetlands, conservation, disasters, natural resources, rivers, and other subjects covered in this document, use the contact information provided in the subject matter areas.	U.S. Census Bureau (573) 884-9122 www.census.gov/ Bureau of Economic Analysis Public Information Office (301) 278-9004 www.bea.gov/ Bureau of Labor Statistics (BLS) Demographic Data Sources (202) 691-5200 Demographic Data Sources (bls.gov) Midwest BLS Kansas City Information Office (312) 353-1880 https://www.bls.gov/regions/midwest/contact.htm Missouri Census Data Center Missouri State Library (417) 895-6670 Missouri Census Data Center Technology Transfer and Economic Development University of Missouri–Rolla (573) 341-6579 https://ecodevo.mst.edu/ Missouri Office of Administration Budget and Planning (573) 751-2345 bpmail@oa.mo.gov https://oa.mo.gov/budget-planning Office of Social and Economic Data Analysis University of Missouri–Columbia

Program/Activity	Type of Assistance	Agency and Contact
Demographics, Societal Statistics and Economic Statistics (continued)		(573) 884-5116 Office of Social and Economic Data Analysis (MU) (umsystem.edu) Center for Economic Information University of Missouri–Kansas City (816) 235-2832 http://cei.umkc.edu/ Missouri Agricultural Statistics Service (314) 595-9594, (800) 551-1014 USDA - National Agricultural Statistics Service - Regional Field Offices Missouri Department of Transportation (573) 751-2551, (888) 275-6636 www.modot.org/ Geographic Resources Center University of Missouri–Columbia (573) 882-2149 www.grc.missouri.edu/ Missouri Economic Research and Information Center (866) 225-8113 MERICData@ded.mo.gov https://www.missourieconomy.org/ Federal Committee on Statistical Methodology FCSM Home | FCSM.gov Missouri Department of Economic Development (573) 751-4962 https://ded.mo.gov/ Missouri Spatial Data Information Service University of Missouri–Columbia (573) 882-3233 http://msdis.missouri.edu

Appendix E

MISSOURI RESIDENTIAL
EARTHQUAKE COVERAGE
2019



STATISTICS SECTION • JULY 2019

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Introduction

Missouri is the third largest market for earthquake insurance among the states, exceeded only by California and Washington.[1] The primary earthquake risk in the state is associated with the New Madrid fault, and is greatest in the Southeast quadrant of the state extending from the bootheel northwards to St. Louis and beyond. However, it is precisely in this high-risk area that the market for earthquake insurance has significantly contracted over the past 20 years – many insurers have left the market entirely, while others refuse to issue new policies in the New Madrid area. Among insurers still willing to sell coverage, stricter underwriting standards make some types of dwellings ineligible for coverage. Those who can obtain coverage find that they are required to "self-insure" to a much greater extent than in the past. Deductibles up to 20 percent of the dwelling value are not uncommon, and "stacked" deductibles are often applied separately to the dwelling and contents. While coverage has contracted, the price of coverage has increased significantly, in some instances by more than 500 percent in some counties over the last 15 years. In short, coverage has become significantly less available and less affordable in the areas that require it most.

This report presents data on some of the market trends over the past 15 years. Missouri is one of the few states that collect residential insurance data by ZIP code, including data for earthquake coverage. These data afford a fairly precise measure of market penetration and price by geographic region. In addition, these data were supplemented by a survey of Missouri's largest writers regarding market practices related to earthquake coverage.

Summary of Findings

Earthquake coverage has become less available and less affordable over the last 15 to 20 years. Where the coverage is available, prices have significantly increased and consumers are required to self-insure to a greater extent than ever before.

- On average, earthquake premiums in the six counties that comprise the New Madrid area have increased by nearly 700 percent between 2000 and 2018, and in one county by nearly 1,000 percent.

- While rates have increased throughout the state, the rates in the highest risk areas of the data have increased much more rapidly, widening the costs between high and low risk areas. In 2000, average annual premium in the New Madrid area was only 64 percent higher than the lowest risk counties of Missouri. By 2018, premiums were nearly 334 percent higher.

- In 2000, over 60 percent of residences in the New Madrid area had earthquake insurance. By 2018, the rate of coverage had declined to just under 14 percent, a decrease of 46 percentage points.

- In other high risk areas outside of the New Madrid zone, take-up rates also substantially decreased, from 67.6 percent to 46.3 percent over the same period.

[1] Including territories, Puerto Rico also has a somewhat higher premium volume for earthquake insurance. However, Puerto Rico is a special case, in that earthquake insurance is required for most residences.

- Nearly half a million residences that are not covered for earthquake losses are located in a Missouri county rated 7 or higher on the Mercalli scale (a measurement of vulnerability to a New Madrid earthquake, see below). The total property value of these unprotected residences, excluding the value of contents that may also be at risk, is estimated to approach $100 billion.

- Based on the Missouri market share for homeowners insurance,
    - Carriers with 12.5 percent of the home insurance market either write no earthquake coverage anywhere in the state, or only renew existing earthquake policies but won't issue new coverage
    - Significantly more, or 31 percent, write somewhere in Missouri, but will not provide new coverage in the New Madrid area (though some of these still offer renewal coverage)
    - 41 percent issue some new coverage in the New Madrid area, but will not insure some types of construction, such as masonry homes.
    - Only 26.6 percent of the market issues coverage in New Madrid on the same basis as elsewhere in the state, but even these companies may have significant additional underwriting restrictions based on the age and location of the home and other construction characteristics

- Those able to obtain earthquake insurance must still "self-insure" to a significant degree. In the six-county New Madrid area, only one insurer (among those surveyed) offers a deductible of less than 10 percent of the insured value of the residence. Over 27 percent of the market requires a deductible of 15 percent or higher. Often, deductibles are "stacked," such that they apply separately to the building and contents.

- Of those who have earthquake coverage and are located in areas with a risk of 7 or higher on the Mercalli 10-point scale, the amount of risk they still retain due to deductibles exceeds $14.5 billion. When this amount is added to homes that have no earthquake coverage, the value of self-insured residential property in moderate to high-risk zones exceeds $110 billion.

In the following report, these trends are displayed by Missouri region and by county.

Missouri's Earthquake Risk

Over the winter of 1811-1812, the New Madrid area of Missouri experienced a series of powerful earthquakes. By most estimates, these quakes were among the strongest ever experienced on the continental US, at least since settlement by Europeans. According to the US Geological Survey (USGS), the area of strong ground motion exceeded the 1964 Alaska earthquake by a factor of two to three, and was approximately ten times as large as the 1909 San Francisco earthquake. Because of the lack of instrumentation at the time, estimates must be based on written accounts of those who witnessed the quake or its aftermath. The majority of researchers believe the three primary quakes ranged in magnitude from 7.0 to 7.5, with several aftershocks ranging from 6.0 to 6.5 (see USGS, https://earthquake.usgs.gov/earthquakes/events/1811-1812newmadrid/summary.php).

Eyewitness accounts of the event(s) vividly describe the extraordinary violence unleashed by the New Madrid fault. One eyewitness close to the epicenter of the December 11, 2011 earthquake details "…a scene truly horrible:"

On the 16th of December, 1811, about two o'clock, A.M., we were visited by a violent shock of an earthquake, accompanied by a very awful noise resembling loud but distant thunder, but more hoarse and vibrating, which was followed in a few minutes by the complete saturation of the atmosphere, with sulphurious vapor, causing total darkness. The screams of the affrighted inhabitants running to and fro, not knowing where to go, or what to do - the cries of the fowls and beasts of every species - the cracking of trees falling, and the roaring of the Mississippi - the current of which was retrograde for a few minutes, owing as is supposed, to an irruption in its bed -- formed a scene truly horrible.[2]

Strong tremors and some property damage were reported as far away as Cleveland (where a local newspaper reported "serious alarm" at "shocks far more violent than any before experienced"), Alexandria, Pittsburgh, Washington D.C., New York and other eastern cities.

Were an earthquake of similar magnitude to occur today along the New Madrid fault, losses would be staggering. The risk modeling firm AIR Worldwide has estimated that a New Madrid recurrence would produce *insured* losses of $120 billion (2011 dollars). Such losses would only be rivaled by a repeat of the 1906 San Francisco earthquake, with estimated losses of $93 billion.

Estimated Insured Losses Were Event to Happen Today			
Date	**Event Location**	**Magnitude**	**Insured Losses (2011 Dollars)**
February 7, 1812	New Madrid, Mo	7.7	$120 billion
April 17, 1906	San Francisco, CA	7.9	$93 billion
August 31, 1886	Charleston, SC	7.3	$44 billion
June 1, 1838	San Francisco, CA	7.4	$30 billion
January 17, 1994	Northridge, CA	6.7	$23 billion
October 21, 1868	Hayward, CA	7.0	$23 billion
January 9, 1857	Fort Tejon, CA	7.9	$8 billion
October 17, 1989	Loma Prieta, CA	6.3	$7 billion
March 10, 1933	Long Beach, CA	6.4	$5 billion
July 1, 1911	Calaveras, CA	6.4	$4 billion

Source: AIR Worldwide. Estimated losses include property and contents loss, additional living expense, business interruption for residential, mobile home, commercial and automobile losses. Estimates include demand surge and fire following earthquake, and are based on earthquake insurance take-up rates in each area. See http://www.air-worldwide.com/Publications/AIR-Currents/2012/Top-10-Historical-Hurricanes-and-Earthquakes-in-the-U-S---What-Would-They-Cost-Today/

[2] Letter from Eliza Bryan, March 22, 1816. Reprinted by USGS, available at http://hsv.com/genlintr/newmadrd/accnt1.htm

The USGS has estimated that the probability of a magnitude 7.5 or greater earthquake in the New Madrid zone over the next 50 years is between 7%-10%. The probability of an earthquake exceeding magnitude 6 over the same time period is 25% - 40%.[3] A joint assessment by the Mid-American Earthquake Center of the University of Illinois and the Federal Emergency Management Agency predicted that a major New Madrid event could entail total economic losses of $300 billion, surpassing the highest total economic loss of any natural disaster in US history. The report is worth quoting at length:

"Nearly 715,000 buildings are damaged in the eight-state study region. About 42,000 search and rescue personnel working in 1,500 teams are required to respond to the earthquakes. Damage to critical infrastructure (essential facilities, transportation and utility lifelines) is substantial in the 140 impacted counties near the rupture zone, including 3,500 damaged bridges and nearly 425,000 breaks and leaks to both local and interstate pipelines. Approximately 2.6 million households are without power after the earthquake. Nearly 86,000 injuries and fatalities result from damage to infrastructure. Nearly 130 hospitals are damaged and most are located in the impacted counties near the rupture zone. There is extensive damage and substantial travel delays in both Memphis Tennessee, and St. Louis, Missouri, thus hampering search and rescue as well as evacuation. Moreover roughly 15 major bridges are unusable. Three days after the earthquake, 7.2 million people are still displaced and 2 million people seek temporary shelter. Direct economic losses for the eight states total nearly $300 billion, while indirect losses may be at least twice this amount."[4]

The Missouri counties most vulnerable to earthquake risk are the six southeastern-most counties in the bootheel: Dunklin, Mississippi, New Madrid, Pemiscot, Scott and Stoddard. Other high risk areas include counties adjacent to the New Madrid Region, extending north to St. Louis. The entire western portion of the state has a relatively lower risk for earthquake damage, a fact important for Missouri earthquake insurance market.

The Mercalli Scale, a measure of shaking intensity ranging from 1 to 12, is depicted in the map on the following page. If a large New Madrid event were to occur today, large portions of the state would be subjected to shaking ranging from 7 to 10 on this scale. The remainder of the state would be subject to shaking intensity rated at a level of 6. The levels are defined by the intensity of ground movement, as follows:

6 – *Strong*. Felt by nearly everyone. Loose objects and some windows may be broken, and unstable objects overturned.

7 – *Very Strong*. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures. Poorly built or badly designed structures will experience considerable damage.

8 – *Severe*. Damage is slight in specially designed structures, but considerable in ordinary substantial buildings which may partially collapse. Damage is great in poorly built structures. Fallen chimneys, factory stacks, columns, and walls will not be uncommon. Heavy furniture may be overturned.

9 – *Violent*. Damage is considerable even in specially designed structures. Well-designed frame structures will be thrown out of alignment. Damage will be great in substantial buildings, with partial collapse. Buildings will be shifted off foundations. Some underground pipes will be broken. Reservoirs suffer severe damage.

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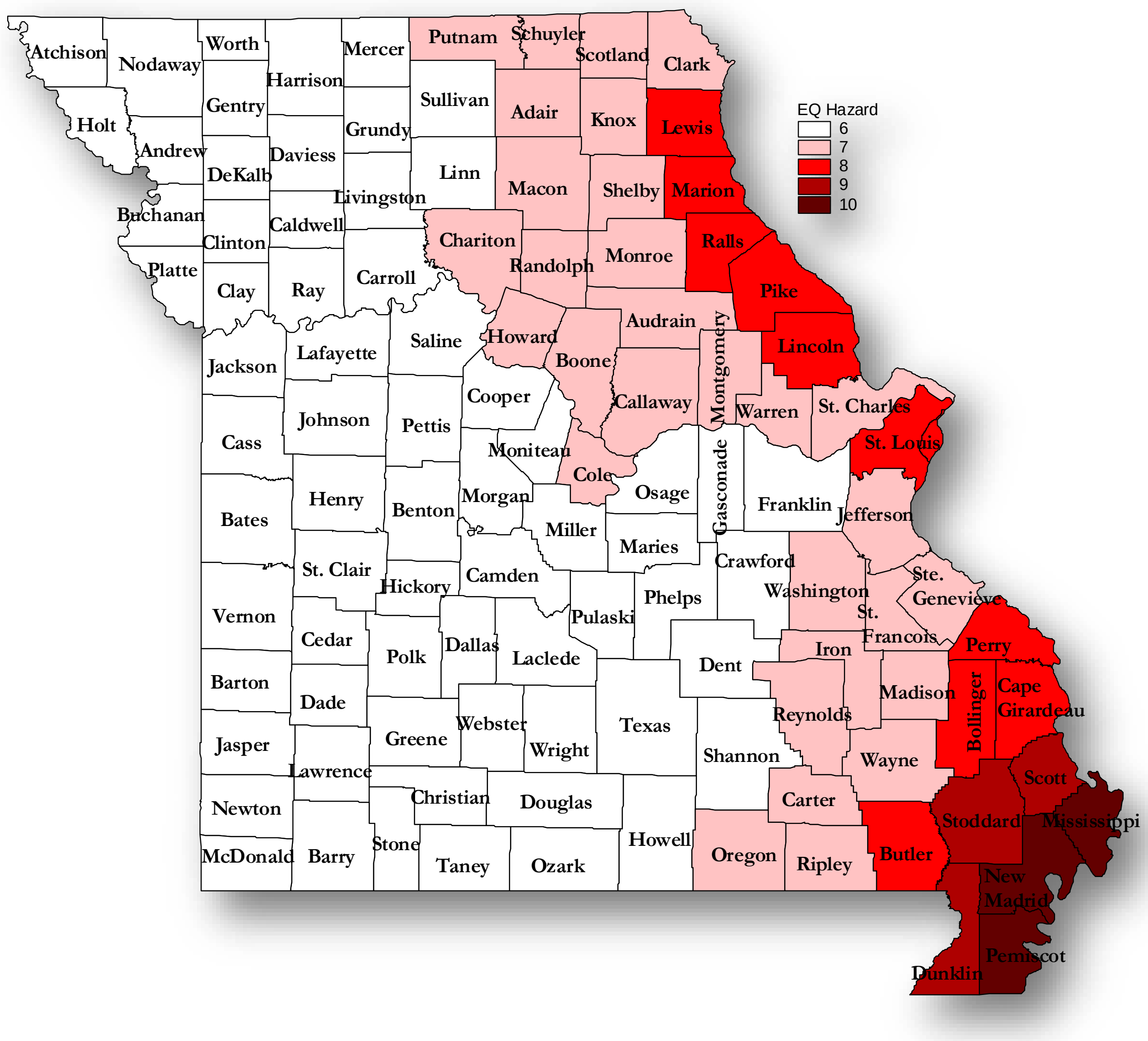
[3] US Geological Survey Fact Sheet FS-131-02. October, 2002.
[4] Elnashai, Amr, Lisa Cleveland, Theresa Jefferson and John Harrald. 2009. Impact of New Madrid Seismic Zone Earthquakes on the Central USA, Vol I & II. MAE Center Report No. 09-03

10 – *Extreme*. Some well-built wooden structures will be totally destroyed. Most masonry and frame structures along with foundations will be destroyed. Bridges and dams may be severely damaged or destroyed. Large landslides will occur, and water thrown from the banks of rivers and lakes.

Mercalli Scale

(Projected Intensity Associated with Possible New Madrid Earthquake)



Source: Adapted from the Missouri State Emergency Management Agency.

Background: Managing Risk with Insurance Markets

Earthquake insurance markets possess features that depart significantly from what might be called "ideal" insurance markets, and such peculiarities are largely attributable to the nature of the underlying risk. In competitive markets, the price of a product reflects the cost of production plus administrative expenses and a normal rate of return (and, of course, elasticity of demand). Unlike traditional and particularly tangible products, the cost of insurance isn't known with certainty at the time the price is established and the product sold. To price in a meaningful way, insurers require a high degree of confidence that predictions regarding likely losses are accurate. The greater the uncertainty regarding the true risk and ultimate payout in claims, the less well a market will function in the traditional sense. Of course, this same uncertainty regarding the true nature of the risk is shared by consumers, potentially creating additional problems on the demand side of the market.

Traditionally, the most predictable and therefore insurable events are those characterized by high frequency and low severity losses. Statistical models rely on the "law of large numbers," such that the more one is able to observe an event over time, the greater the certainty that meaningful probabilities of loss can be ascertained.[5] In addition, risks are manageable because losses of this kind are *statistically independent events*. The probability that Driver B in Kansas City will be involved in an automobile accident on a given day isn't affected by the fact that Driver A in St. Louis experienced a crash. While automobile and homeowners insurance can be subject to catastrophic large-scale losses due to a single event, such losses are manageable and are generally a small proportion of overall losses when extended over a sufficient time period. Most automobile losses, for example, are due to day-to-day crashes whose costs are highly predictable over time, and where loss probabilities aren't subject to significant swings from year-to-year. In general, prior year losses are a very good predictor of current year losses.

Clearly, earthquake insurance markets depart from the idealized features discussed above in several important ways. First, the likelihood of a significant event cannot be determined with a high degree of confidence and precision, certainly not in a way that is analogous to predicting automobile losses. Secondly, rather than "high frequency / low severity" losses, earthquakes present exactly the opposite risk in which losses are very infrequent (in Missouri) but have the potential to be catastrophic. Nor are losses *independent events* – a loss on one policy will quite possibly entail losses of virtually every policy within the area of risk. Lastly, known earthquake risk in Missouri is largely localized to the southeastern quadrant of the state, so there is little incentive for individuals residing outside of the high risk zone to purchase coverage (and in fact few homeowners in low risk areas have earthquake coverage). It is therefore difficult to spread risk geographically using traditional market mechanisms.

Many of these types of events have at various times in history become uninsurable by private markets. Some risks have been assumed by public bodies in whole or in part when private markets failed to produce adequate or affordable coverage. Examples include flood insurance, crop insurance and the terrorism risk backstop, where at various times such risks were considered too unpredictable and possible losses too catastrophic for the private market to insure them via normal market operation. Similarly, after the 1994

[5] The "law of large numbers" explains why predictions about the ratio of heads to tales in a coin flip are much more accurate for 1,000 flips than 10 flips; or why larger sample sizes are more precise (have smaller margins of errors).

Northridge Earthquake, the public California Earthquake Authority was established to stabilize the market, and it currently issues more than three-fourths of all residential earthquake policies in the state.[6]

Alternative Risk Management Mechanisms –Reinsurance

As noted above, primary insurance markets cannot easily accommodate risks when hazards are geographically localized. As discussed further below, few individuals residing outside the area of highest risk are likely to purchase coverage, and they are likely to be much more sensitive to price. An insurer willing to provide earthquake coverage will inevitably experience a degree of "adverse selection," and find that insureds are concentrated where the risk is greatest and minimal where the risk is least.

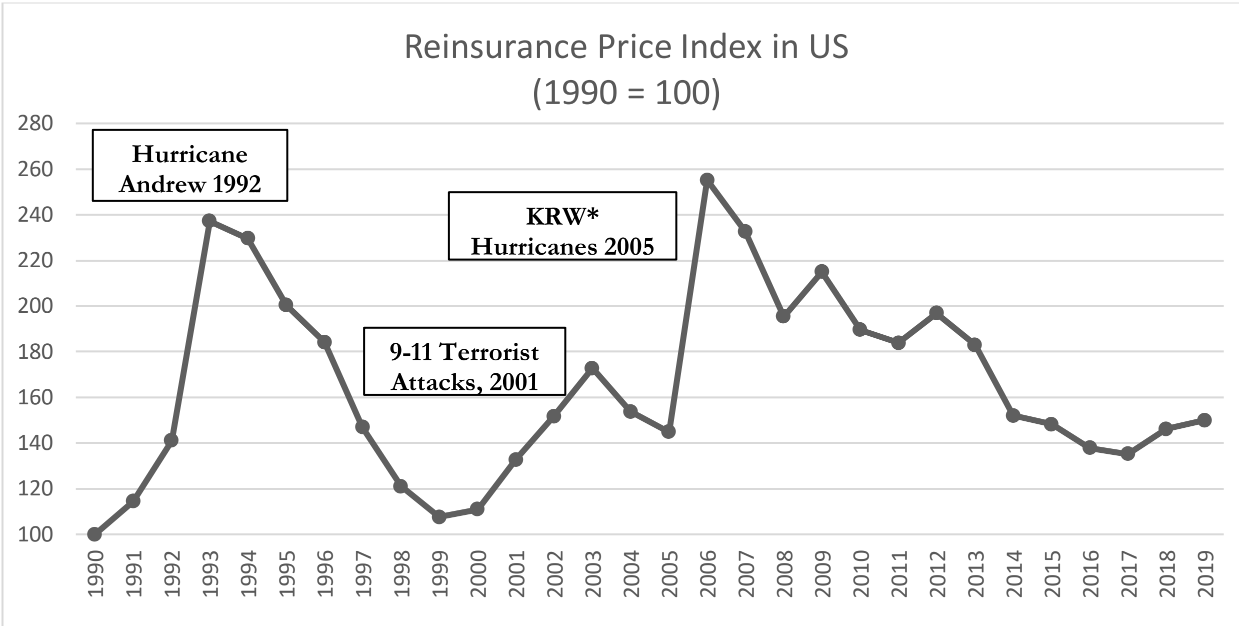
However, there are alternative market mechanisms available. One such mechanism is *reinsurance* - essentially insurance for insurance companies. Large reinsurers operate on a global scale, and primary insurers can transfer significant portions of the risk associated with a book of business to these entities in exchange for a premium. As might be expected, earthquake coverage is highly reinsured. In 2018, a little over 70 percent of direct earthquake premium was ceded to reinsurance.[7] Other mechanisms include catastrophe bonds, or securities issued by insurers to pass risk on to investors. Total outstanding catastrophe bonds amounted to more than $20 billion in 2015 and cover risks such as hurricanes and earthquakes.[8]

Reinsurance markets work well to manage catastrophic risks such as earthquakes. However, high dependence on reinsurance means that prices and availability of primary coverage is sensitive to the price of reinsurance. This sensitivity means that events unrelated to Missouri's earthquake risk can impact the price of insurance coverage in Missouri. For example, reinsurance became more expensive and less available after Katrina. However, the cost of reinsurance remains well below the peak of 2007, and does not appear to account for current market retractions in Missouri.

[6] California Earthquake Authority. 2017 Report to the Legislature. August, 2018. This report can be found on the CEA's website at www.earthquakeauthority.com

[7] Calculated from insurers' financial annual statements, Exhibit of Premium Written.

[8] ARTEMIS. Q1 2015 Catastrophe Bond and ILS Market Report.



*****Katrina, Rita & Wilma**.**
******The deepening financial crisis also had a significant impact on the price of reinsurance
Source: Adapted from Guy Carpenter, ROL Index for US

Missouri's Contracting Earthquake Insurance Market

As the previous discussion makes clear, it doesn't appear that a lack of access to reinsurance accounts for the deterioration of the Missouri earthquake market, particularly in recent years. Rather, it appears that insurers have either determined that the New Madrid fault presents a risk greater than previously believed or, as is the case of at least one major insurer, less tolerance to insure all catastrophe risks. Allstate announced in 2006 that it was pulling out of the earthquake market in all states, describing it as a general business decision to reduce exposure to all forms of catastrophe risks.[9] At the time, Allstate had provided earthquake insurance to over 37,000 Missouri residences.

Other companies quickly followed Allstate's lead. Between 2000 and 2018, 72 insurers exited the Missouri earthquake market. Between them, these insurers had provided coverage to over 124,000 residences in 2000. While 39 insurers entered the market over the same time period, those carriers only insured 68,909 policies in 2018. Over the same period, companies that remained in the market stopped writing in high risk areas or tightened underwriting criteria, scaled back the amount and type of coverage offered, and dramatically increased prices. The net result of these market practices has been a significant decline in the number of earthquake policies issued. Since 2000, the number of homeowners policies with earthquake coverage declined by more than a quarter, from 670,968 in 2000 to 492,591 in 2018.

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[9] Jolayne Hoytz. Allstate Ends Quake Coverage. **The Seattle Times,** 6/2/2006.

The remainder of this report examines these trends in detail. The figures in the following tables are derived from two primary data sources. Information pertaining to premium and policy counts[10] by geographic region is derived from residential insurance data collected by ZIP Code, pursuant to 20 CSR 600-3.100 (see http://www.sos.mo.gov/adrules/csr/current/20csr/20c600-3.pdf). Additional information was obtained by a survey of homeowners writers in the state. In 2018, insurers with a combined homeowners insurance market share of 96 percent completed a questionnaire regarding market practices with respect to providing earthquake coverage.

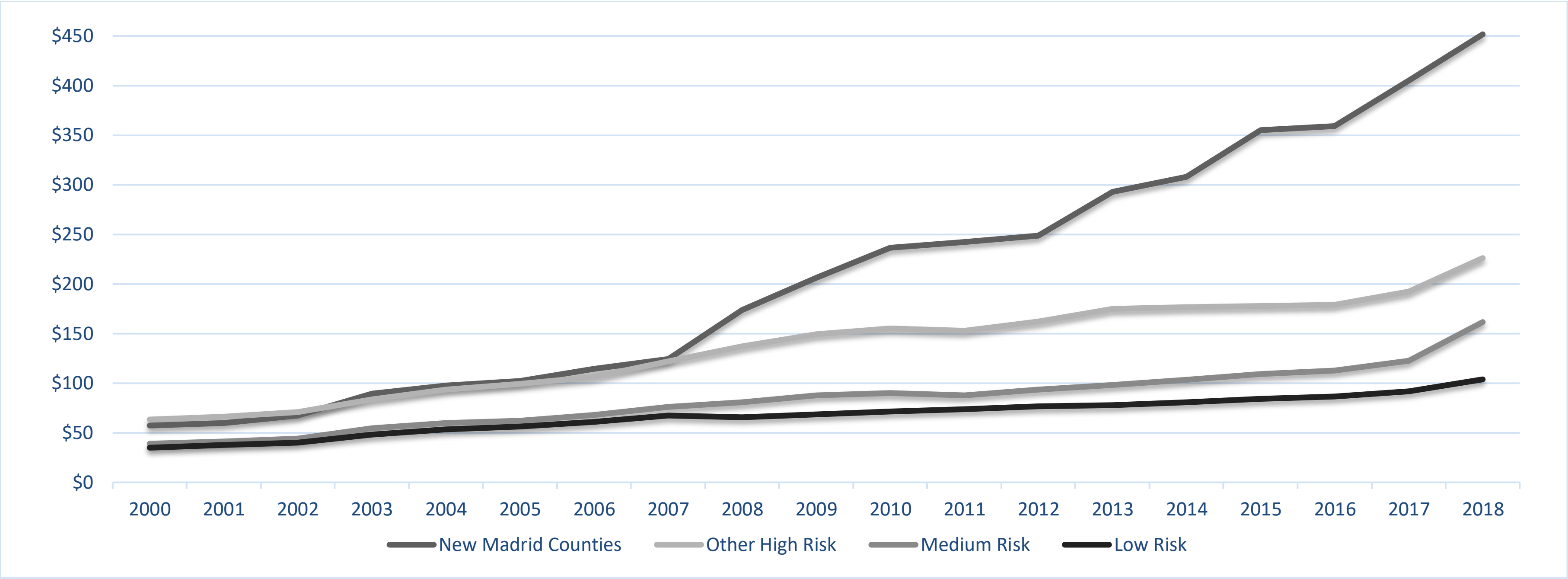
The Rising Cost of Coverage in a Declining Market

In 2000, residential earthquake coverage was readily available and inexpensive, even in the highest risk areas of the state. In that year, residents in the New Madrid region of Missouri[11] paid on average $57 per year for such coverage, an amount not significantly higher than the $35 annual premium paid by residents of the lowest risk area. Over the next 15 years, rates increased substantially, primarily within higher risk areas. By 2015, the average premium in the New Madrid area had increased by 523% to $357. While premiums also increased elsewhere in the state, the rate of increase was substantially less than experienced in New Madrid. In the lowest risk areas, premiums increased by 173% over the same time period.

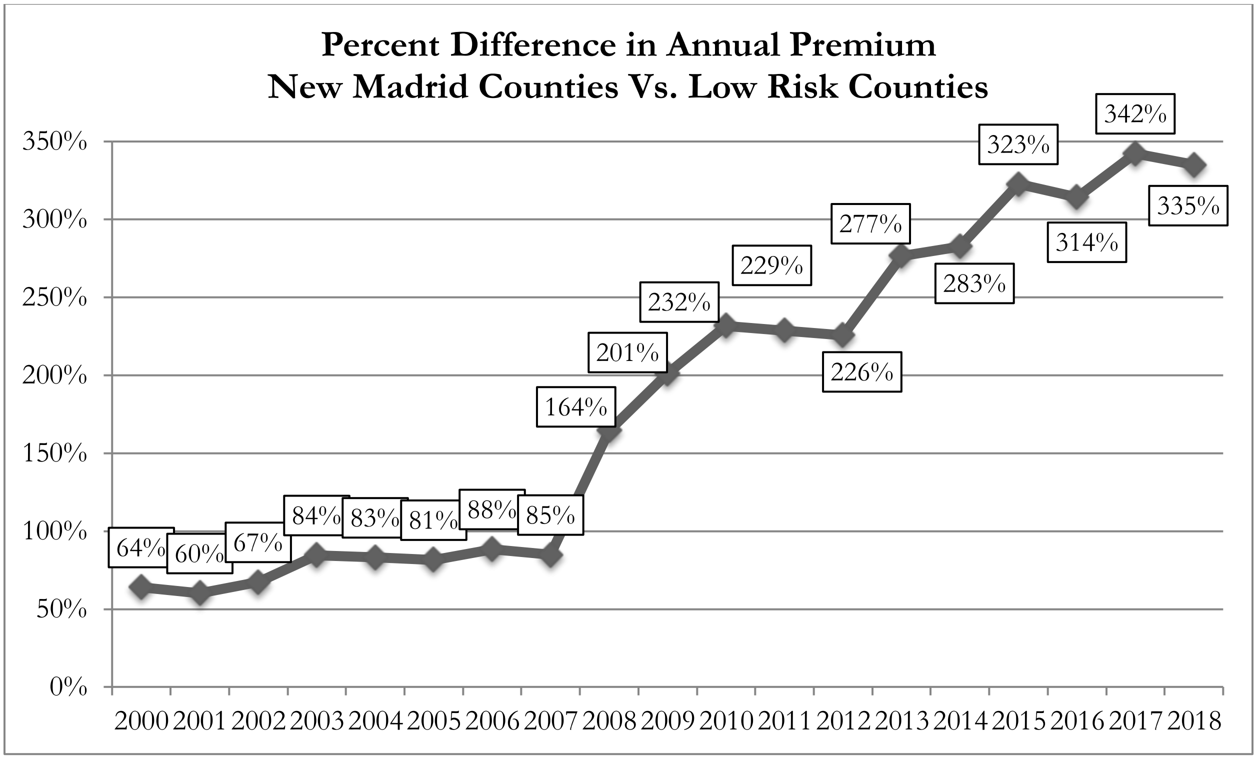
[10] Or, more strictly speaking, "exposures" rather than policy counts. The term "exposure" is equivalent to coverage for one residence for one year. Two six month policies issued in a year would count as a single exposure. To avoid overuse of specialized terminology, the terms "policies" or "covered residences" are used in this report.

[11] For purposes of this report, the region is composed of the six southeastern-most counties in Missouri: Dunklin, Mississippi, New Madrid, Pemiscot, Scott and Stoddard.

Average Annual Cost of EQ Coverage													
Region	**2000**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
New Madrid Counties	$57	$124	$174	$206	$236	$242	$249	$293	$308	$355	$359	$405	$452
Other High Risk Counties	$63	$122	$137	$149	$155	$153	$162	$175	$177	$178	$179	$192	$226
Medium Risk Counties	$39	$76	$80	$88	$90	$88	$94	$98	$104	$109	$113	$122	$161
Low Risk Counties	$35	$67	$66	$69	$71	$74	$76	$78	$81	$84	$87	$92	$104
MO Total	**$50**	**$97**	**$106**	**$115**	**$119**	**$117**	**$124**	**$131**	**$134**	**$137**	**$146**	**$149**	**$179**
% Difference-Highest v Lowest Risk Counties	62.9%	85.1%	163.6%	198.6%	232.4%	227.0%	227.6%	275.6%	280.2%	322.6%	312.6%	340.2%	334.6%

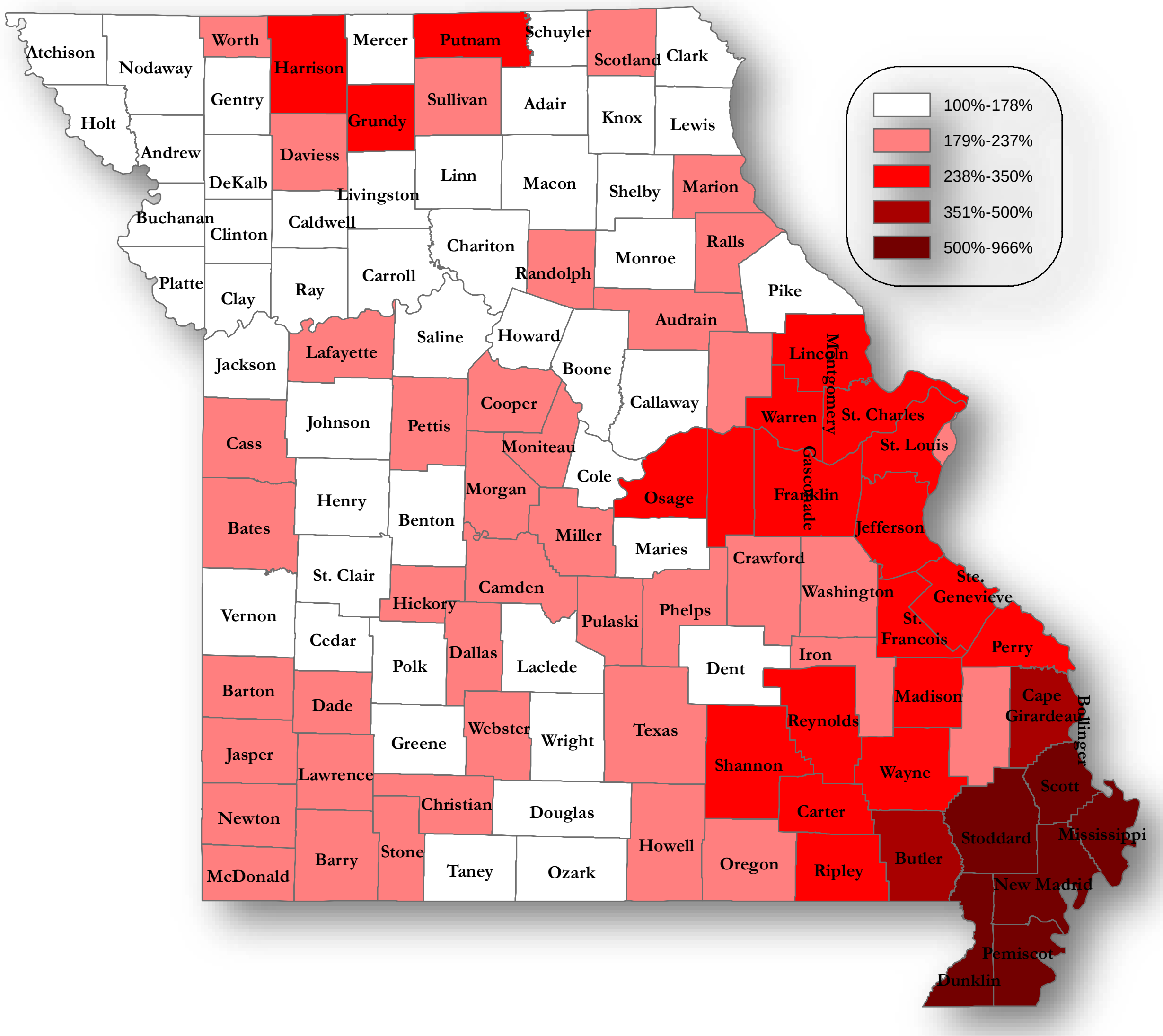


As a result of these trends, the gap in costs widened between high- and low-risk areas. In 2000, premiums in New Madrid were only 64% higher than the lowest-risk areas. The gap increased dramatically in 2008, and by 2015 had grown to 274%.



The map below depicts the change in annual premium by county. The reader will note that the rate of increase was significantly higher in counties most at risk. A table of these same data can be found in Appendix A.

% Change in Average Premium for Earthquake Coverage, 2000-2018



Declining Take-up Rates

In 2000, nearly 44 percent of all Missouri residences had earthquake coverage. In the New Madrid area, over 60 percent of homes were covered, and in other high risk areas, including St. Louis, the take-up rate was almost 70 percent. In New Madrid, the take-up rate had declined to less than 50 percent in 2008, and by 2018 had declined much further to below 14 percent. Thus, six of every seven homes in the six-county New Madrid area lacked earthquake coverage last year. The decline was less precipitous in the second highest risk area, though by 2016 less than half of residences had coverage. In the lowest risk area, comprised of the western portion of the state, coverage rates declined by nearly 9 percentage points, to 13.3 percent (see illustrations on the following page). As depicted in the following table, only in 6 counties were more than half of residences covered.

% of Residences With Earthquake Coverage	# of Counties	Number of Owner-Occupied Homes & Mobile Homes*
Less than 10%	41	215,112
10%-19.9%	44	707,197
20%-29.9%	15	203,664
30%-39.9%	6	56,175
40%-49.9%	3	62,848
50%-59.9%	5	407,778
60%-69.9%	1	119,825
Total	**115**	**1,772,603**

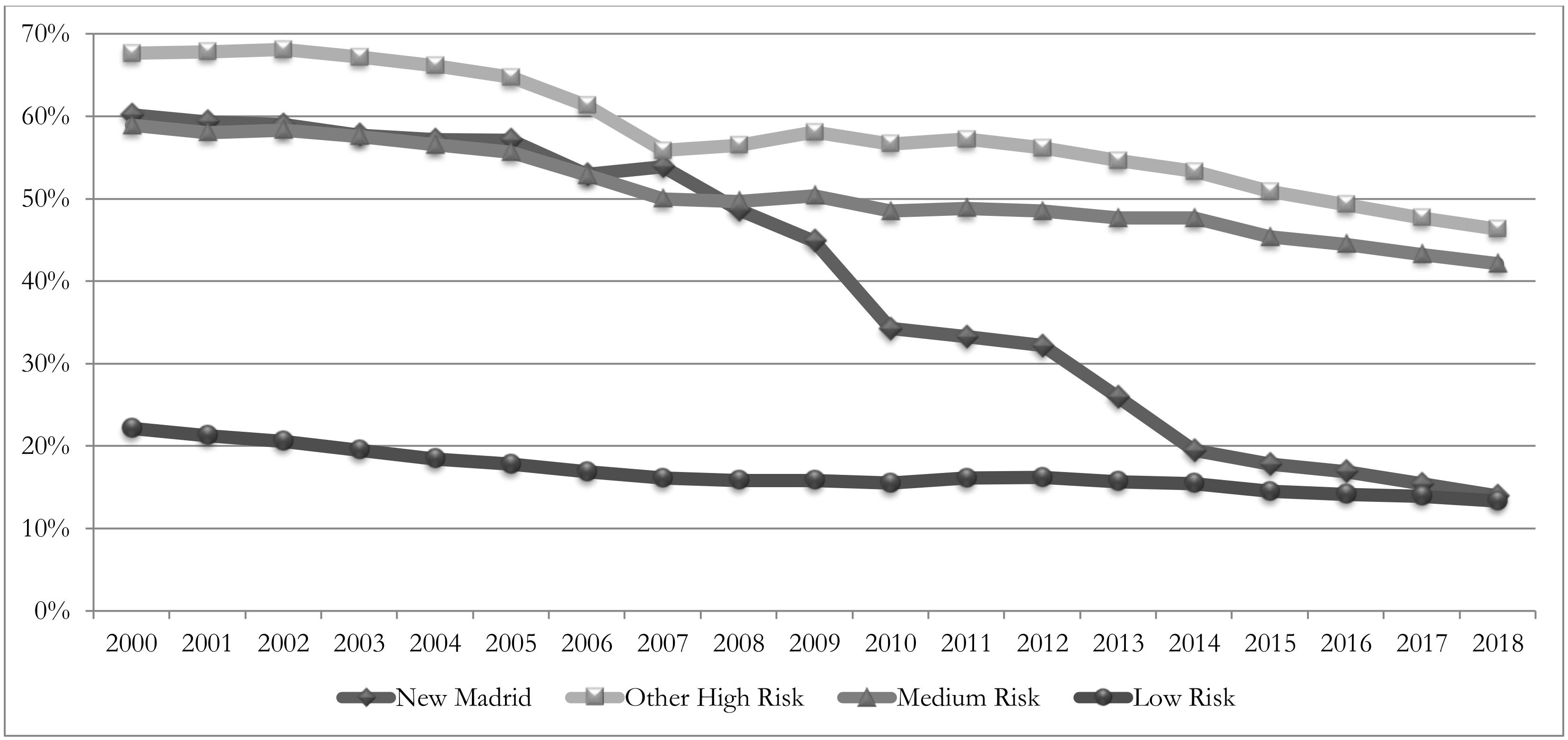
**Based on insured dwellings. A small percentage of homes that have no insurance coverage are excluded.*

In the highest risk areas, including all counties rated seven or higher on the Mercalli Scale (see map, page 3), nearly 500,000 private residences (excluding rental properties) lacked earthquake coverage in 2018. The estimated value of these uninsured residences totaled nearly $100 billion, excluding the value of the contents.

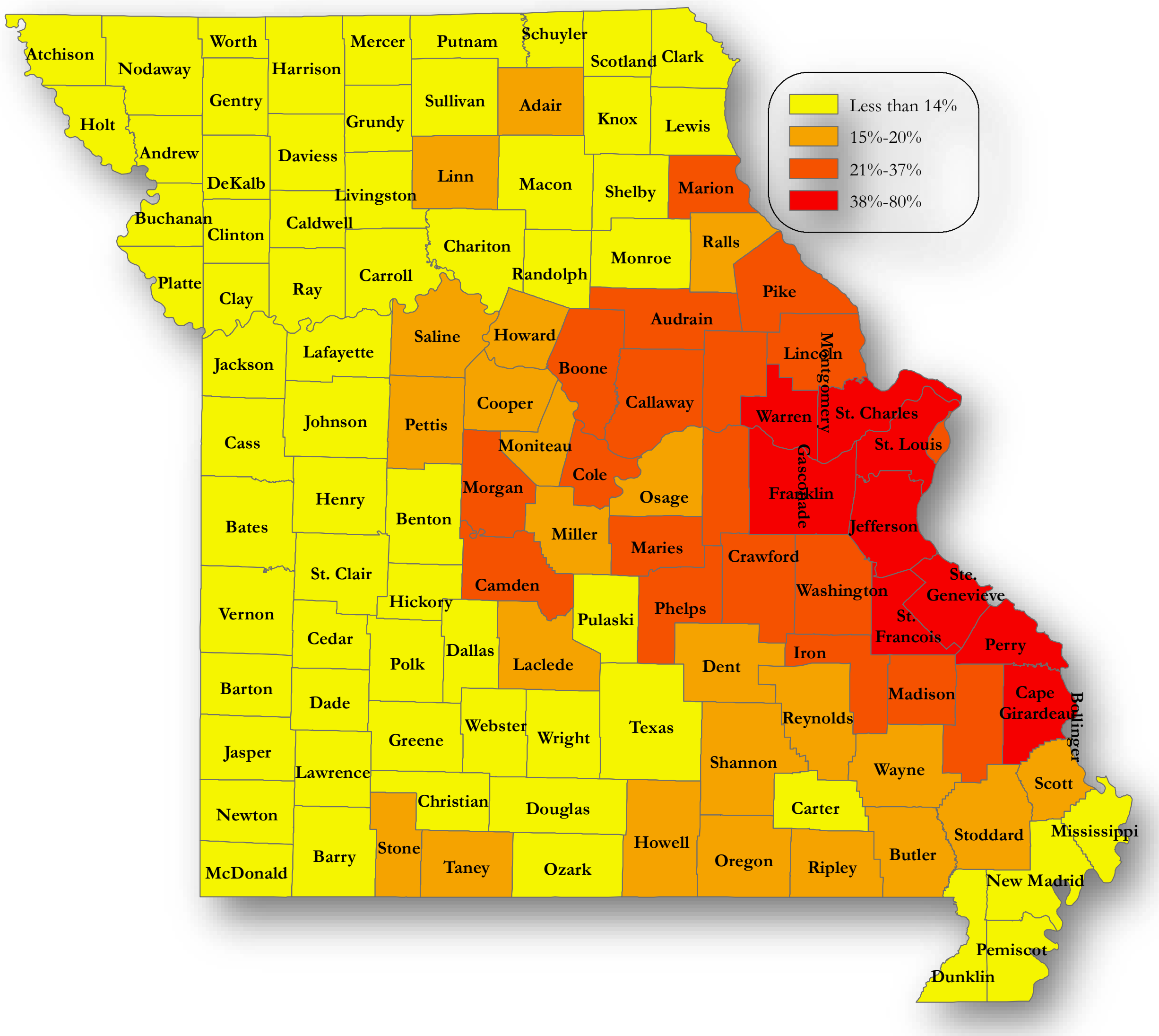
Value of Dwellings Not Insured for Earthquake Damage (uninsured homes plus value retained under deductible on insured homes)				
Earthquake Risk (Mercalli Scale)	**Uninsured Dwellings**	**Uninsured Property Value**	**Amounts Under Deductible on Insured Residences**	**Total**
7	262,798	$50,665,730,833	$5,936,484,313	$56,602,215,146
8	192,014	$40,620,827,083	$8,376,305,188	$48,997,132,271
9	29,405	$3,833,162,500	$152,944,125	$3,986,106,625
10	11,798	$1,367,817,500	$36,403,688	$1,404,221,188
7 or higher	**496,015**	**96,487,537,916**	**14,502,137,314**	**$110,989,675,230**

Source: Estimates produced by DIFP.

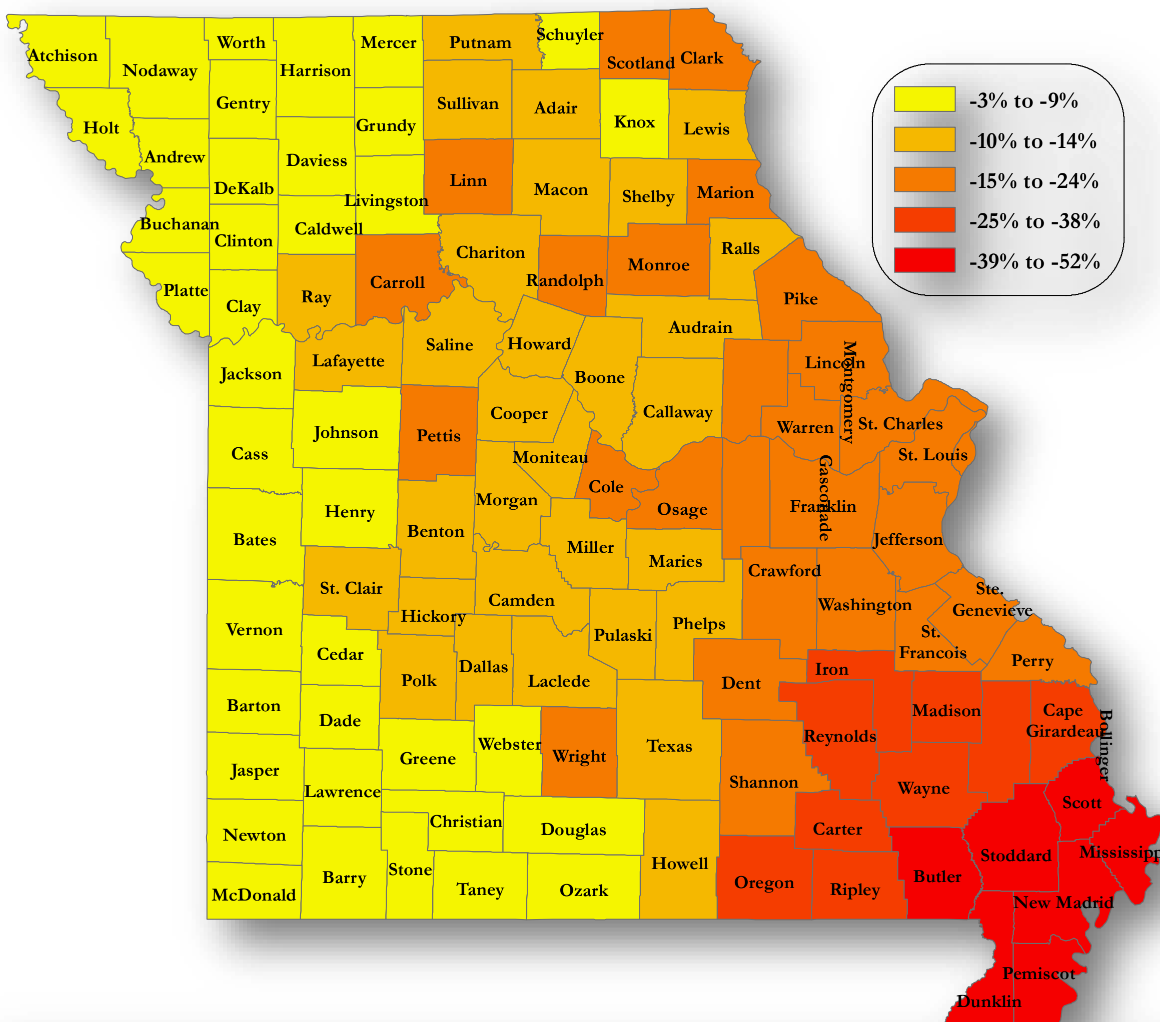
Percent of Residences with Earthquake Coverage														
Region	**2000**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Pct Point Diff.**
New Madrid	60.2%	53.9%	48.6%	44.9%	34.3%	33.3%	32.2%	25.9%	19.7%	17.8%	16.9%	17.1%	13.9%	46.3%
Other High Risk	67.6%	55.8%	56.5%	58.1%	56.6%	57.2%	56.1%	54.6%	53.5%	50.9%	49.3%	48.6%	46.3%	21.3%
Medium Risk	58.9%	50.0%	49.7%	50.4%	48.5%	48.8%	48.5%	47.6%	47.7%	45.3%	44.5%	45.8%	42.1%	16.8%
Low Risk	22.1%	16.1%	15.9%	15.8%	15.5%	16.1%	16.2%	15.7%	15.5%	14.5%	14.1%	14.7%	13.3%	8.8%
MO Total	**43.6%**	**35.2%**	**35.0%**	**35.4%**	**34.2%**	**34.6%**	**34.4%**	**33.2%**	**32.9%**	**30.6%**	**28.5%**	**30.2%**	**27.8%**	**15.8%**



Percent of Residences with Earthquake Insurance, 2018



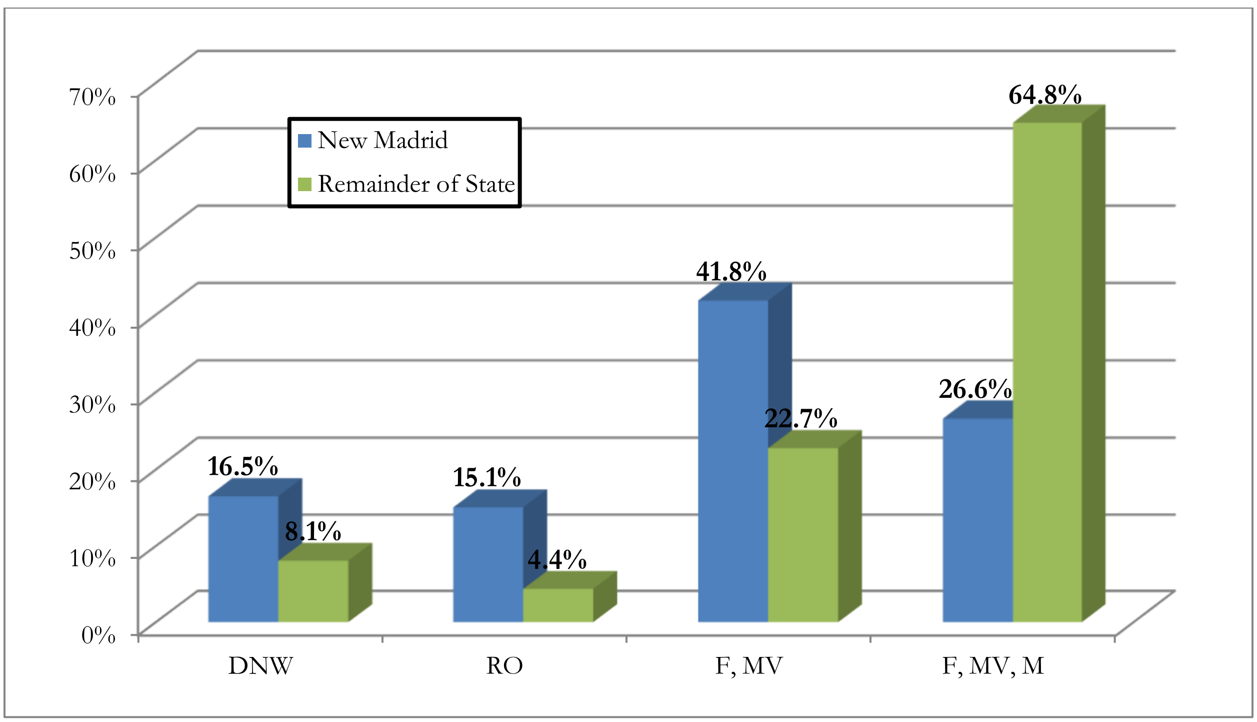
Residences With Earthquake Insurance, Percentage Point Change, 2000-2018



Declining Quality of Coverage

Based on survey responses from carriers representing over 97 percent of the homeowners market, most insurers still sell earthquake coverage in at least in some areas of the state. Weighting responses by market share, approximately 88 percent of the market still offers the coverage on both renewal and new business. However, coverage is far less available within the high-risk New Madrid area. Among respondents, nearly one-third of the market does not write new earthquake coverage at all in New Madrid (though a portion of these will renew existing earthquake business). An additional 41 percent of the market places significant additional underwriting restrictions on residences in the area, the chief restriction being that masonry homes are ineligible for coverage. In addition, residents of New Madrid may be subject to significantly higher deductibles. Only about a fourth of the market issues coverage in New Madrid on the same terms as elsewhere in the state.

Earthquake Insurance Availability, by Percent of Homeowners Market New Madrid Area vs. Remainder of the State



Source: DIFP survey of homeowners insurers

DNW: Does Not Write Earthquake Insurance

RO: Renewals Only

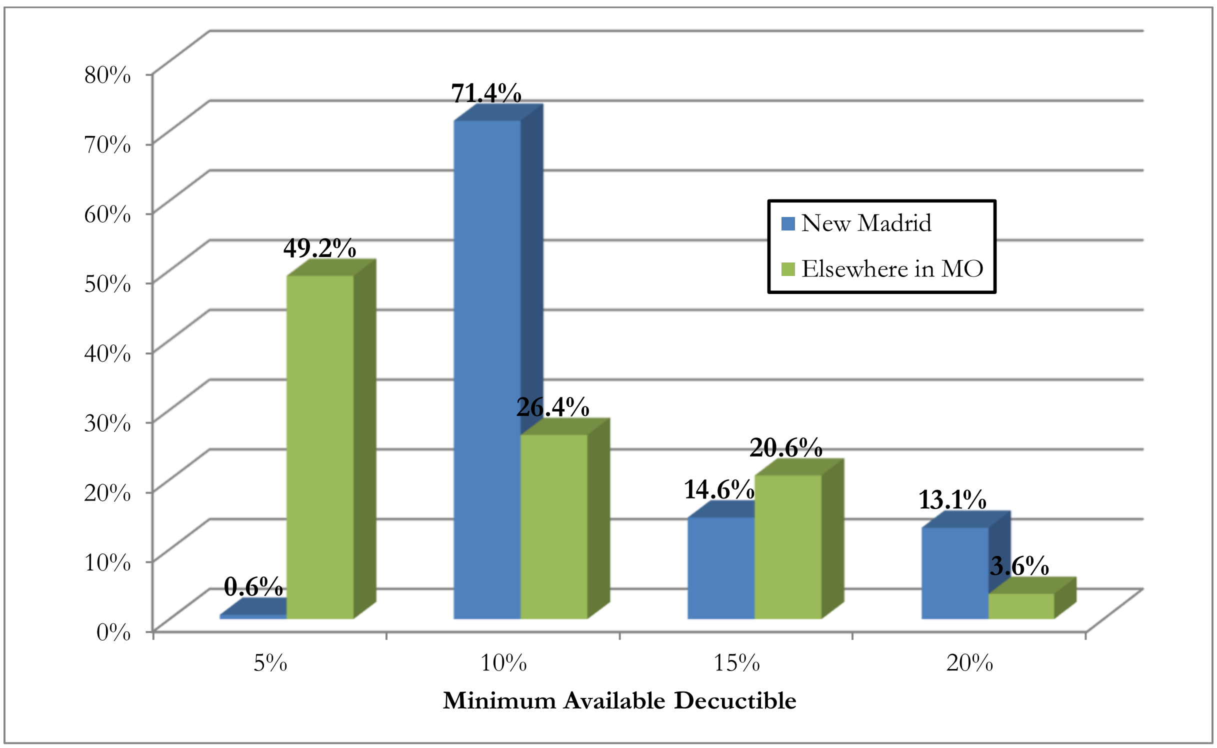
F, MV: Will provide coverage for Frame and Masonry Veneer residences, but not structures constructed with solid masonry

F, MV, M: Provides coverage for all construction types.

Even individuals with earthquake coverage are increasingly required to "self-insure" to a significant extent. Earthquake insurance typically requires deductibles specified as a percentage of the insured value of the dwelling. For example, a $200,000 home with a 10% deductible would require a homeowner to pay the first $20,000 of a claim before insurance would extend coverage. In addition, "stacked" deductibles are common, so that separate deductibles are applied to the dwelling and contents, so that hypothetical insured described above would be retain up to $40,000 of risk.

Based on the DIFP survey, about half the market offers a 5% deductible policy *outside of the New Madrid area,* though virtually no insurers offer such policies to New Madrid residents. In the six-county New Madrid area, 71 percent of insurers (weighted by market share) require a 10 percent deductible, and over a quarter require a deductible of 15% or higher.

% of Market by Minimum Available Deductible



Source: DIFP survey of homeowners insurers

Conclusion

Missouri's earthquake insurance market has significantly contracted over the past 10 to 15 years. Relatively few insurers issue earthquake coverage in the New Madrid region without significant underwriting restrictions. For example, many refuse to cover specific kinds of residences, such as masonry homes. At the same time, the price of residential earthquake insurance has increased significantly; in the highest risk area of the state average premiums paid have increased by over 700 percent since 2000. Even when homeowners can obtain coverage, they still must retain a large portion of the risk. Virtually no insurer surveyed offered a policy with a deductible of less than 10 percent of the value of the insured dwelling, while over 40 percent required a deductible of 20 percent or higher. As a result, many individuals have dropped earthquake coverage, and the market has contracted most dramatically in the New Madrid area. In 2000, over 60 percent of dwellings in the six-county New Madrid area had earthquake coverage. By 2018, less than 14 percent had such coverage. The DIFP estimates that Missouri residential property valued at nearly $110 billion is exposed to significant earthquake risk but is not insured.

A comparison with Joplin is instructive. Struck by a devastating EF5 tornado on May 22, 2011, the insurance industry responded rapidly and within three months over $1 billion was made available to insureds. By June of the following year, more than $1.5 billion had been paid by insurers, who would eventually cover more than $2 billion in tornado-related losses.[12] Almost all structures were covered for this type of loss, resulting in a rapid infusion of funds that made recovery possible. Such a recovery mechanism is almost entirely lacking in the area of the state most vulnerable to a New Madrid earthquake.

[12] Based on a special data call of all P&C insurers active in Missouri.

Appendix A:
Average Annual Earthquake Premiumby County
(New Madrid counties are highlighted)

County	2000	2005	2010	2015	2018	% Change, 2000-2018
Adair	$31	$52	$58	$62	$75	140.0%
Andrew	$30	$51	$52	$58	$78	158.1%
Atchison	$35	$52	$65	$78	$86	144.5%
Audrain	$30	$50	$59	$70	$89	200.5%
Barry	$30	$50	$64	$80	$95	213.6%
Barton	$27	$42	$47	$64	$87	222.2%
Bates	$33	$62	$83	$81	$101	200.2%
Benton	$26	$38	$46	$57	$67	159.6%
Bollinger	$48	$82	$105	$126	$160	234.4%
Boone	$44	$77	$89	$93	$110	149.9%
Buchanan	$34	$52	$63	$70	$84	150.2%
Butler	$64	$100	$175	$254	$324	403.9%
Caldwell	$29	$59	$65	$65	$72	151.1%
Callaway	$32	$55	$66	$73	$89	174.8%
Camden	$36	$55	$76	$90	$114	219.8%
Cape Girardeau	$68	$107	$178	$245	$334	392.7%
Carroll	$30	$37	$48	$60	$71	137.1%
Carter	$34	$61	$101	$105	$137	307.4%
Cass	$35	$57	$68	$80	$104	197.4%
Cedar	$31	$48	$59	$71	$79	155.5%
Chariton	$29	$56	$66	$55	$73	149.2%
Christian	$37	$60	$74	$87	$104	181.1%
Clark	$29	$41	$50	$56	$62	113.1%
Clay	$36	$55	$62	$74	$94	165.7%
Clinton	$34	$55	$57	$64	$84	150.4%
Cole	$43	$62	$77	$93	$113	163.7%
Cooper	$33	$49	$61	$82	$95	190.9%
Crawford	$30	$54	$63	$69	$87	191.6%
Dade	$27	$43	$55	$69	$87	228.5%
Dallas	$28	$44	$53	$75	$84	200.4%
Daviess	$31	$61	$67	$75	$87	180.1%
DeKalb	$37	$55	$57	$70	$80	115.4%
Dent	$31	$53	$66	$67	$78	156.0%
Douglas	$27	$39	$42	$59	$64	131.3%
Dunklin	$57	$112	$234	$420	$514	808.2%
Franklin	$37	$64	$96	$111	$153	313.6%
Gasconade	$29	$47	$65	$82	$105	267.0%
Gentry	$32	$59	$75	$72	$82	154.8%

Greene	$39	$60	$73	$88	$106	172.6%
Grundy	$27	$40	$56	$75	$96	252.8%
Harrison	$24	$33	$44	$67	$84	250.9%
Henry	$30	$51	$62	$65	$77	160.6%
Hickory	$24	$34	$43	$58	$81	235.5%
Holt	$35	$55	$73	$76	$86	150.6%
Howard	$29	$54	$64	$64	$78	171.7%
Howell	$31	$62	$76	$73	$88	189.7%
Iron	$32	$50	$71	$80	$100	215.2%
Jackson	$41	$62	$73	$87	$103	150.7%
Jasper	$31	$47	$60	$77	$95	202.4%
Jefferson	$38	$59	$88	$107	$166	340.1%
Johnson	$33	$59	$64	$76	$84	150.6%
Knox	$27	$50	$54	$60	$66	147.3%
Laclede	$30	$46	$60	$74	$78	157.6%
Lafayette	$29	$50	$57	$70	$85	187.8%
Lawrence	$27	$44	$63	$76	$89	227.4%
Lewis	$25	$48	$60	$58	$68	167.1%
Lincoln	$34	$59	$74	$80	$137	301.1%
Linn	$27	$37	$40	$47	$59	119.2%
Livingston	$28	$41	$47	$57	$71	151.5%
McDonald	$23	$39	$50	$61	$74	219.6%
Macon	$27	$50	$52	$56	$73	171.1%
Madison	$34	$55	$82	$108	$126	273.0%
Maries	$29	$52	$62	$64	$74	152.6%
Marion	$29	$50	$60	$64	$81	179.9%
Mercer	$28	$39	$50	$54	$63	125.9%
Miller	$26	$46	$57	$67	$85	227.0%
Mississippi	$52	$97	$235	$338	$403	683.1%
Moniteau	$27	$50	$59	$67	$86	212.4%
Monroe	$26	$49	$57	$58	$72	177.2%
Montgomery	$31	$54	$68	$76	$101	228.2%
Morgan	$26	$42	$51	$65	$82	219.9%
New Madrid	$54	$85	$281	$378	$502	823.8%
Newton	$27	$42	$55	$68	$82	199.2%
Nodaway	$33	$58	$62	$65	$76	128.3%
Oregon	$33	$56	$69	$89	$99	194.9%
Osage	$32	$85	$107	$102	$130	301.2%
Ozark	$28	$42	$45	$55	$69	147.1%
Pemiscot	$48	$97	$248	$420	$513	965.7%
Perry	$42	$63	$95	$142	$178	320.7%
Pettis	$27	$42	$51	$65	$78	185.0%
Phelps	$32	$54	$68	$77	$94	191.4%

Pike	$36	$61	$75	$76	$92	158.6%
Platte	$46	$70	$81	$99	$114	145.8%
Polk	$31	$47	$60	$74	$86	175.7%
Pulaski	$29	$58	$74	$86	$96	227.3%
Putnam	$30	$56	$67	$92	$118	294.8%
Ralls	$27	$45	$57	$59	$86	220.9%
Randolph	$25	$41	$52	$60	$73	196.2%
Ray	$32	$52	$64	$68	$82	157.0%
Reynolds	$31	$63	$86	$81	$107	249.7%
Ripley	$38	$59	$82	$126	$146	286.3%
Saint Charles	$42	$66	$100	$122	$191	349.6%
Saint Clair	$28	$45	$55	$73	$78	178.1%
Sainte Genevieve	$42	$62	$87	$130	$163	288.5%
Saint Francois	$35	$61	$79	$94	$123	255.1%
Saint Louis	$64	$101	$157	$179	$227	253.0%
Saline	$28	$39	$52	$62	$75	168.2%
Schuyler	$27	$45	$58	$61	$60	124.9%
Scotland	$27	$44	$56	$69	$78	186.0%
Scott	$65	$106	$274	$380	$493	656.3%
Shannon	$28	$53	$73	$97	$103	267.8%
Shelby	$27	$49	$56	$57	$66	141.1%
Stoddard	$54	$101	$169	$258	$337	519.4%
Stone	$37	$54	$72	$85	$106	184.8%
Sullivan	$22	$36	$41	$55	$66	198.0%
Taney	$34	$49	$61	$72	$84	146.7%
Texas	$30	$57	$68	$77	$86	182.8%
Vernon	$28	$44	$54	$65	$74	160.9%
Warren	$36	$56	$80	$92	$141	294.4%
Washington	$30	$44	$54	$71	$87	189.8%
Wayne	$34	$53	$84	$117	$145	330.7%
Webster	$33	$54	$77	$89	$111	237.8%
Worth	$29	$32	$52	$60	$95	224.7%
Wright	$32	$44	$52	$66	$79	148.5%
Saint Louis City	$68	$103	$167	$181	$211	209.2%
Total	**$50**	**$79**	**$119**	**$137**	**$179**	**260.6%**

Appendix B

Percent of Residences With Earthquake Coverage
(New Madrid Counties are Highlighted)

County	2000	2005	2010	2015	2018	Percentage Point Difference, 2000-2018
Adair	29.1%	22.9%	20.1%	17.0%	14.7%	-14.4%
Andrew	18.5%	14.9%	12.5%	10.8%	9.9%	-8.6%
Atchison	10.2%	8.4%	8.0%	6.9%	6.7%	-3.5%
Audrain	36.2%	31.9%	30.8%	26.6%	24.2%	-11.9%
Barry	15.4%	11.7%	8.9%	8.6%	8.8%	-6.7%
Barton	12.6%	9.8%	7.8%	7.1%	5.7%	-6.8%
Bates	13.0%	8.6%	5.9%	5.5%	4.7%	-8.3%
Benton	22.4%	16.9%	14.7%	13.2%	12.1%	-10.4%
Bollinger	62.4%	57.1%	38.9%	33.1%	30.9%	-31.4%
Boone	37.6%	29.8%	27.0%	25.4%	24.3%	-13.2%
Buchanan	16.5%	12.9%	11.2%	9.6%	8.9%	-7.7%
Butler	57.3%	51.8%	33.8%	20.4%	17.0%	-40.3%
Caldwell	11.4%	7.8%	6.6%	6.5%	5.6%	-5.8%
Callaway	37.5%	31.9%	27.0%	25.5%	24.0%	-13.5%
Camden	42.1%	40.0%	37.5%	35.8%	32.8%	-9.2%
Cape Girardeau	81.2%	79.5%	71.9%	59.3%	55.1%	-26.1%
Carroll	23.0%	16.6%	10.6%	9.9%	8.3%	-14.7%
Carter	47.7%	42.4%	20.7%	16.2%	13.6%	-34.1%
Cass	19.4%	13.9%	11.6%	11.1%	10.7%	-8.7%
Cedar	14.3%	11.7%	9.1%	8.1%	6.5%	-7.8%
Chariton	24.0%	18.3%	15.9%	16.0%	12.2%	-11.8%
Christian	16.1%	11.6%	11.8%	10.7%	9.6%	-6.5%
Clark	22.3%	17.1%	12.6%	9.6%	7.5%	-14.8%
Clay	20.5%	15.2%	13.0%	12.3%	11.9%	-8.7%
Clinton	15.3%	10.7%	8.8%	7.8%	8.0%	-7.3%
Cole	43.5%	37.9%	32.5%	29.5%	26.5%	-17.0%
Cooper	26.9%	20.5%	15.7%	16.1%	15.0%	-11.9%
Crawford	45.4%	42.9%	36.2%	32.1%	28.2%	-17.2%
Dade	12.5%	9.1%	7.5%	6.8%	5.9%	-6.5%
Dallas	15.8%	9.7%	6.6%	6.0%	5.1%	-10.8%
Daviess	9.9%	6.2%	5.2%	5.4%	5.0%	-4.9%
DeKalb	8.9%	6.5%	4.3%	4.3%	4.1%	-4.8%
Dent	32.3%	24.8%	20.4%	18.0%	14.5%	-17.7%
Douglas	12.6%	10.5%	10.4%	8.8%	7.7%	-4.9%
Dunklin	55.7%	47.3%	30.4%	14.0%	11.2%	-44.5%

Franklin	64.5%	61.4%	52.6%	49.5%	45.7%	-18.8%
Gasconade	48.9%	48.1%	42.9%	38.0%	29.8%	-19.1%
Gentry	12.9%	8.8%	7.2%	6.7%	5.2%	-7.7%
Greene	18.7%	14.1%	13.0%	11.9%	11.0%	-7.8%
Grundy	12.8%	9.9%	7.3%	6.7%	5.5%	-7.3%
Harrison	8.7%	6.1%	4.4%	4.5%	4.4%	-4.3%
Henry	20.1%	16.6%	14.6%	13.7%	11.9%	-8.2%
Hickory	19.4%	14.7%	10.9%	9.7%	8.1%	-11.2%
Holt	9.4%	5.4%	4.8%	4.4%	3.7%	-5.7%
Howard	32.5%	26.9%	23.6%	22.9%	20.1%	-12.4%
Howell	33.5%	27.9%	24.2%	23.3%	19.5%	-14.0%
Iron	56.8%	49.4%	36.9%	35.8%	30.3%	-26.5%
Jackson	17.1%	12.9%	11.3%	11.1%	10.5%	-6.6%
Jasper	18.2%	15.6%	13.8%	14.1%	12.6%	-5.6%
Jefferson	72.8%	70.0%	60.0%	56.5%	53.2%	-19.6%
Johnson	20.1%	14.5%	12.2%	12.3%	11.7%	-8.4%
Knox	16.4%	13.3%	11.8%	10.2%	8.3%	-8.1%
Laclede	28.4%	23.4%	20.6%	17.4%	15.2%	-13.2%
Lafayette	23.2%	16.1%	13.3%	13.2%	11.8%	-11.4%
Lawrence	15.0%	10.2%	7.8%	8.1%	6.8%	-8.2%
Lewis	22.9%	18.5%	16.1%	13.6%	10.7%	-12.3%
Lincoln	53.8%	49.8%	44.4%	42.0%	38.0%	-15.8%
Linn	30.6%	27.0%	23.7%	19.8%	15.7%	-14.9%
Livingston	15.7%	11.1%	11.6%	10.0%	8.9%	-6.8%
Mcdonald	13.5%	7.5%	5.8%	5.7%	5.2%	-8.3%
Macon	24.7%	17.9%	17.3%	14.6%	12.0%	-12.7%
Madison	65.7%	59.9%	39.5%	37.9%	36.9%	-28.8%
Maries	31.0%	29.7%	22.4%	24.1%	21.5%	-9.4%
Marion	41.5%	36.2%	33.9%	28.8%	26.3%	-15.2%
Mercer	10.2%	7.2%	5.7%	5.3%	4.3%	-5.9%
Miller	24.3%	20.5%	17.4%	16.7%	14.5%	-9.8%
Mississippi	60.1%	54.1%	30.0%	13.3%	8.7%	-51.4%
Moniteau	24.2%	20.3%	19.1%	16.4%	15.0%	-9.2%
Monroe	31.6%	25.0%	21.3%	18.1%	13.4%	-18.2%
Montgomery	47.2%	42.4%	36.6%	31.7%	29.6%	-17.7%
Morgan	35.6%	33.7%	30.4%	26.8%	24.0%	-11.5%
New Madrid	51.2%	54.8%	27.7%	14.9%	12.3%	-38.9%
Newton	14.0%	9.6%	8.5%	9.0%	8.2%	-5.8%
Nodaway	7.1%	5.2%	4.7%	4.4%	4.0%	-3.1%
Oregon	42.7%	36.8%	24.1%	23.5%	18.4%	-24.3%
Osage	33.3%	28.4%	23.8%	20.6%	18.3%	-15.0%
Ozark	18.5%	15.8%	14.1%	12.9%	12.4%	-6.1%
Pemiscot	49.4%	45.7%	21.1%	12.3%	11.0%	-38.4%

Perry	77.4%	79.2%	71.9%	66.8%	58.5%	-18.9%
Pettis	30.9%	25.3%	19.2%	16.0%	15.4%	-15.5%
Phelps	34.7%	28.9%	25.6%	24.4%	22.2%	-12.4%
Pike	41.3%	35.8%	30.3%	25.4%	22.0%	-19.2%
Platte	18.8%	14.3%	12.3%	12.1%	12.3%	-6.5%
Polk	17.8%	11.9%	10.5%	10.0%	8.3%	-9.4%
Pulaski	25.9%	18.9%	13.4%	13.1%	12.4%	-13.5%
Putnam	16.5%	9.9%	6.9%	7.3%	6.4%	-10.1%
Ralls	31.2%	27.1%	25.7%	24.5%	20.6%	-10.6%
Randolph	30.9%	24.9%	20.5%	17.0%	13.9%	-17.0%
Ray	19.0%	14.1%	11.4%	10.7%	8.9%	-10.1%
Reynolds	42.4%	32.6%	21.4%	18.7%	17.6%	-24.9%
Ripley	44.3%	41.7%	24.4%	18.0%	16.0%	-28.4%
Saint Charles	79.2%	75.4%	67.0%	63.7%	60.1%	-19.1%
Saint Clair	14.9%	9.8%	6.0%	5.9%	5.4%	-9.4%
Sainte Genevieve	76.1%	75.9%	68.7%	64.0%	54.0%	-22.1%
Saint Francois	65.4%	64.5%	56.7%	50.7%	45.2%	-20.2%
Saint Louis	74.4%	70.7%	62.9%	57.8%	53.1%	-21.3%
Saline	25.7%	21.6%	19.3%	18.2%	15.8%	-9.9%
Schuyler	13.9%	12.5%	9.5%	6.4%	5.2%	-8.6%
Scotland	20.9%	13.8%	12.1%	9.4%	5.8%	-15.0%
Scott	70.0%	67.9%	41.5%	22.7%	18.0%	-52.1%
Shannon	31.3%	22.3%	19.0%	17.0%	14.7%	-16.5%
Shelby	21.9%	16.0%	14.4%	14.3%	10.5%	-11.3%
Stoddard	63.9%	61.4%	42.2%	20.7%	15.3%	-48.7%
Stone	18.1%	15.2%	14.6%	14.8%	14.5%	-3.6%
Sullivan	14.9%	9.3%	7.1%	5.7%	4.7%	-10.2%
Taney	20.2%	18.1%	17.0%	16.8%	16.2%	-4.0%
Texas	24.6%	18.9%	14.2%	11.8%	10.9%	-13.7%
Vernon	17.0%	12.2%	9.8%	8.9%	8.9%	-8.1%
Warren	60.7%	59.3%	49.5%	49.0%	45.1%	-15.6%
Washington	53.9%	48.2%	37.2%	36.1%	30.9%	-23.0%
Wayne	51.9%	43.1%	25.1%	18.8%	16.8%	-35.1%
Webster	17.8%	13.1%	11.5%	10.8%	9.4%	-8.4%
Worth	7.8%	5.3%	4.8%	4.5%	4.8%	-3.0%
Wright	23.9%	18.0%	13.9%	11.8%	9.1%	-14.8%
Saint Louis City	46.1%	45.9%	36.2%	30.5%	26.1%	-20.1%
Total	**43.6%**	**39.8%**	**34.2%**	**30.6%**	**27.8%**	**-15.8%**

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Trust for America's Health

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Trust for America's Health (**TFAH**) is a nonprofit, nonpartisan public health policy, research, and advocacy organization that promotes optimal health for every person and community, and that makes the prevention of illness and injury a national priority.

The **Johns Hopkins Bloomberg School of Public Health** is dedicated to the improvement of health for all people through the discovery, dissemination, and translation of knowledge, and the education of a diverse global community of research scientists, public health professionals, and others in positions to advance the public's health.

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Report Authors

Matt McKillop, MPP
Senior Health Policy Researcher and Analyst
Trust for America's Health

Rachel Pittluck, MPH
Consultant
Trust for America's Health

Jonathan M. Links, Ph.D.
Professor, Public Health, Medicine, Education, Engineering, and Business
Vice Provost and Chief Risk and Compliance Officer
Johns Hopkins University

Megan Weil Latshaw, Ph.D.
Associate Scientist
Johns Hopkins Bloomberg School of Public Health

Crystal R. Watson, DrPH
Senior Scholar, Johns Hopkins Center for Health Security
Assistant Professor
Johns Hopkins Bloomberg School of Public Health

Tara Kirk Sell, Ph.D.
Senior Scholar, Johns Hopkins Center for Health Security
Assistant Professor
Johns Hopkins Bloomberg School of Public Health

Report Contributors

Caroline Anitha Devadason, MPH
Former Health Policy Researcher and Analyst
Trust for America's Health

Qi Wang, Ph.D. candidate
Department of Civil and Systems Engineering
Johns Hopkins Whiting School of Engineering

Brenda Dimaya, B.S.
Former Intern
Trust for America's Health

Emma Holland, B.S.
Graduate Student
Johns Hopkins Bloomberg School of Public Health

Evans K. H. Brown, M.D.
Postdoctoral Fellow
Johns Hopkins University School of Medicine

Jura Augustinavicius, Ph.D.
Assistant Scientist
Johns Hopkins Bloomberg School of Public Health

Ann Rose, B.S.
Graduate Student
Johns Hopkins Bloomberg School of Public Health

Peer Reviewers

This report benefited from the insights and expertise of the following external reviewers. Although they have reviewed the report, neither they nor their organizations necessarily endorse its findings or conclusions.

John Balbus, M.D., MPH
Senior Advisor
Public Health National Institute of Environmental Health Sciences (NIEHS)
Director
NIEHS-WHO Collaborating Centre for Environmental Health Sciences

James S. Blumenstock, M.A.
Chief Program Officer
Health Security Association of State and Territorial Health Officials

Anthony D. Moulton, Ph.D.
Senior Fellow
University of Minnesota School of Public Health

Surili Sutaria Patel, M.S.
Director
Center for Climate, Health and Equity
American Public Health Association

Linda Rudolph, M.D., MPH
Senior Advisor
Center for Climate Change and Health
Public Health Institute

Shubhayu Saha, Ph.D.
Health Scientist
Climate and Health Program
National Center for Environmental Health
Centers for Disease Control and Prevention

Paul Schramm, M.S., MPH
Climate Science Team Lead
Climate and Health Program
National Center for Environmental Health
Centers for Disease Control and Prevention

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EXECUTIVE SUMMARY

Climate change poses serious threats to human health. Too often, the issue is framed as a risk for the distant future, but in fact it is here today. It is a reality for communities across the United States, and around the world, many of whom are already dealing with rising seas, longer and more intense heat waves, more powerful hurricanes, warmer winters, and other devastating impacts.

To be sure, climate-related work must address the future. Because carbon dioxide and other greenhouse gases can stay in the atmosphere for hundreds of years, the choices we make today will affect the climate for centuries. By the same token, the release of greenhouse gases through human activities over the past two centuries has made some level of additional global warming inevitable. Since the turn of the 20th century, the average annual temperature across the contiguous United States increased by 1.8 degrees Fahrenheit (1.0 degrees Celsius), and the country can expect to see it rise another 2.5 degrees Fahrenheit (1.4 degrees Celsius) over the next few decades, owing to past emissions. The evidence is clear that the climate is changing and will continue to change for at least the next century. Humans must learn to live with the effects of this change (adaptation), even as they pursue the essential objective of minimizing future warming by reducing greenhouse gas emissions (mitigation).

Climate change, however, does not affect all people and places equally. It is a global phenomenon, but its effects are local, shaped by weather patterns and geography. A person's experience depends, in large part, on where she lives. That experience includes health risks. In addition to the well-understood dangers of death and injury posed by natural disasters, many health outcomes are directly or indirectly linked to environmental factors and, therefore, sensitive to changes in climate. (See Figure 1.)

Figure 1

Examples of Climate-Related Health Impacts

	Climate Driver	Exposure	Health Outcome	Impact
Extreme Heat	More frequent, severe, prolonged heat events	Elevated temperatures	Heat-related death and illness	Rising temperatures will lead to an increase in heat-related deaths and illnesses.
Outdoor Air Quality	Increasing temperatures and changing precipitation patterns	Worsened air quality (ozone, particulate matter, and higher pollen counts)	Premature death, acute and chronic cardiovascular and respiratory illnesses	Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death.
Flooding	Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events	Contaminated water, debris, and disruptions to essential infrastructure	Drowning, injuries, mental health consequences, gastrointestinal and other illness	Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.
Vector-Borne Infection (Lyme Disease)	Changes in temperature extremes and seasonal weather patterns	Earlier and geographically expanded tick activity	Lyme disease	Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.
Water-Related Infection (*Vibrio vulnificus*)	Rising sea surface temperature, changes in precipi-tation and runoff affecting coastal salinity	Recreational water or shellfish contaminated with *Vibrio vulnificus*	*Vibrio vulnificus* induced diarrhea & intestinal illness, wound and blood-stream infections, death	Increases in water temperatures will alter timing and location of *Vibrio vulnificus* growth, increas-ing exposure and risk of water-borne illness.
Food-Related Infection (*Salmonella*)	Increases in temperature, humidity, and season length	Increased growth of pathogens, seasonal shifts in incidence of *Salmonella* exposure	*Salmonella* infection, gastrointestinal outbreaks	Rising temperatures increase *Salmonella* prevalence in food; longer seasons and warming winters increase risk of exposure and infection.
Mental Health and Well-Being	Climate change impacts, especially extreme weather	Level of exposure to traumatic events, like disasters	Distress, grief, behavioral health disorders, social impacts, resilience	Changes in exposure to climate- or weather-related disasters cause or exacerbate stress and mental health consequences, with greater risk for certain populations.

Source: U.S. Global Change Research Program[1]

In addition to environmental factors, social and demographic factors also drive vulnerability, meaning that the health of some communities or people could be more affected than others. Some are more vulnerable because of age (e.g., children, older adults) or preexisting medical conditions (e.g., diabetes, asthma). People who work outdoors or as first responders may face greater exposure. Large portions of other groups, such as immigrants, people of color, people living in poverty, or people experiencing homelessness may have less access to resources that would allow them to avoid exposures, seek care or treatment, or navigate long-term recovery. In many cases, vulnerability to the health impacts of climate change reflect existing health risk factors and disparities. In the United States, the legacy of colonization, slavery, and ongoing structural and systemic racism—including concentrated poverty and inequities in wealth, health, education, housing, and transportation—contribute mightily to disparities between white and nonwhite populations and, in particular, between white and Black and white and Native American populations, making climate change an area of essential importance for the vital missions of health equity and environmental justice.

Protecting people from these health impacts will ultimately require both short- and long-term thinking and action, both local and global perspectives, and both mitigation and adaptation, the primary focus of this report. Some necessary actions will require large-scale cooperation and dramatic shifts in how the nation organizes economic and societal activity. But important opportunities exist at the state and local level, especially with respect to helping people safely navigate their changing environment. This is particularly true for managing the risks to public health. Adaptation, which seeks to reduce injuries, illness, death, and suffering from climate change, can be considered an extension of traditional public health approaches that emphasize prevention and preparedness. In the United States, many of these actions are driven by state-level plans, policies, and programs, which provide a critical foundation and supply of resources to support additional efforts at the community level.

Given the size and diversity of the country, each state and its communities will experience climate change differently. State leaders must understand their particular risks and vulnerabilities in order to plan effectively. In areas of a state where vulnerability is higher, state leaders should invest more in adaptation and preparedness. Likewise, states that are more vulnerable overall should go to greater lengths to adapt to climate-related hazards.

This report examines states' readiness to protect residents from the health impacts of climate change in light of the nature and level of risks that they face. Researchers at Trust for America's Health and the Johns Hopkins Bloomberg School of Public Health developed a set of quantitative indicators to assess each state and the District of Columbia, drawing from three domains of inquiry: (1) vulnerability; (2) public health preparedness; and (3) climate-related adaptation.* American Indian and Alaska Native tribal nations and U.S. territories were not included in the assessment, owing to a lack of comparable data, a serious gap that this country must work to fill, given the acute threat that climate change poses to many of their residents.

* The District of Columbia was treated as a state in this study. Any reference to states generally should be understood to include the District.

The results provide a portrait of state-level preparedness for the health impacts of climate change in the United States. While researchers found that every state had engaged in at least some level of planning and preparation—the extent or effectiveness of plan implementation, critical to preventing adverse outcomes, was not part of the assessment—there was significant variation, and, in many places, a great deal of room for improvement. Of greatest concern, researchers found that states with the highest levels of vulnerability—predominantly located in the Southeast—tended to be among the least prepared. (See Table 1.)

Table 1
States Grouped by Level of Vulnerability and Preparedness

Vulnerability Group	State	Vulnerability Score Least Vulnerable: 3.4-4.7 More Vulnerable: 4.8-5.3 Most Vulnerable: 5.4-6.3	Preparedness Score Least Prepared: 4.0-5.0 More Prepared: 5.1-5.8 Most Prepared: 5.9-6.6
Least Vulnerable	Utah	3.8	6.6
	Maryland	4.4	6.3
	Vermont	4.3	6.3
	Colorado	4.0	6.2
	Wisconsin	4.4	6.1
	New Hampshire	4.1	6.0
	District of Columbia	4.5	5.9
	Maine	4.5	5.9
	Minnesota	4.4	5.8
	Washington	4.5	5.8
	Michigan	4.7	5.8
	Alaska	3.4	5.4
	North Dakota	4.1	5.2
	Nebraska	4.6	5.1
	Idaho	4.2	5.0
	Montana	4.3	4.8
	Wyoming	4.2	4.5
More Vulnerable	Virginia	4.8	6.3
	Massachusetts	4.9	6.2
	Rhode Island	4.9	6.0
	Illinois	4.9	6.0
	New York	5.3	5.9
	Pennsylvania	5.3	5.9
	Connecticut	4.9	5.9
	Oregon	4.8	5.8
	Delaware	4.9	5.7
	Kansas	5.1	5.3
	Iowa	4.9	5.3
	Indiana	5.0	5.0
	Ohio	5.1	5.0
	New Jersey	5.2	4.9
	Hawaii	5.3	4.8
	Nevada	4.9	4.6
	South Dakota	4.8	4.5
Most Vulnerable	North Carolina	5.5	6.0
	Arizona	5.4	5.9
	Alabama	5.8	5.8
	California	5.5	5.8
	Louisiana	5.9	5.7
	New Mexico	5.8	5.7
	Arkansas	6.1	5.5
	Missouri	5.4	5.5
	Florida	6.3	5.1
	Tennessee	5.5	4.9
	Georgia	5.6	4.9
	Kentucky	5.9	4.8
	South Carolina	5.9	4.8
	Texas	5.5	4.6
	Mississippi	5.9	4.5
	Oklahoma	5.5	4.5
	West Virginia	5.8	4.0

"Most prepared," among states that were "least vulnerable."

"Least prepared," among states that were "least vulnerable."

The COVID-19 pandemic is another reminder that long-predicted, seemingly remote health risks must continuously be high priorities for those entrusted with safeguarding Americans. The science is clear that the Earth's climate will continue to change and that those changes will adversely impact human health. Leaders at all levels of government must act with urgency and persistent focus to ensure that their people, particularly those who are most vulnerable, are safe and secure.

Specifically, Trust for America's Health and researchers at the Johns Hopkins Bloomberg School of Public Health offer the following federal and state policy and program recommendations:

Federal recommendations

1. Enact legislation requiring a national strategic plan.
2. Fully fund the Centers for Disease Control and Prevention's (CDC) Climate and Health program.
3. Provide funding for adaptation research and scientific training.
4. Fully fund the CDC's National Environmental Public Health Tracking Network.
5. Strengthen the public health infrastructure and its workforce, including by modernizing data and surveillance capacities.
6. Prioritize equity and resilience by supporting and protecting high-risk populations and by addressing the social determinants of health.

State recommendations

1. Bolster states' core public health preparedness capabilities.
2. Build health equity leadership in state and local governments.
3. Complete all steps of the CDC's Building Resilience Against Climate Effects (BRACE) framework, and continuously work to enhance and refine preparations.
4. Establish ongoing, dedicated funding and staff for climate-related preparations.
5. Engage in close coordination with local and federal partners.
6. Plan with communities, not for them.

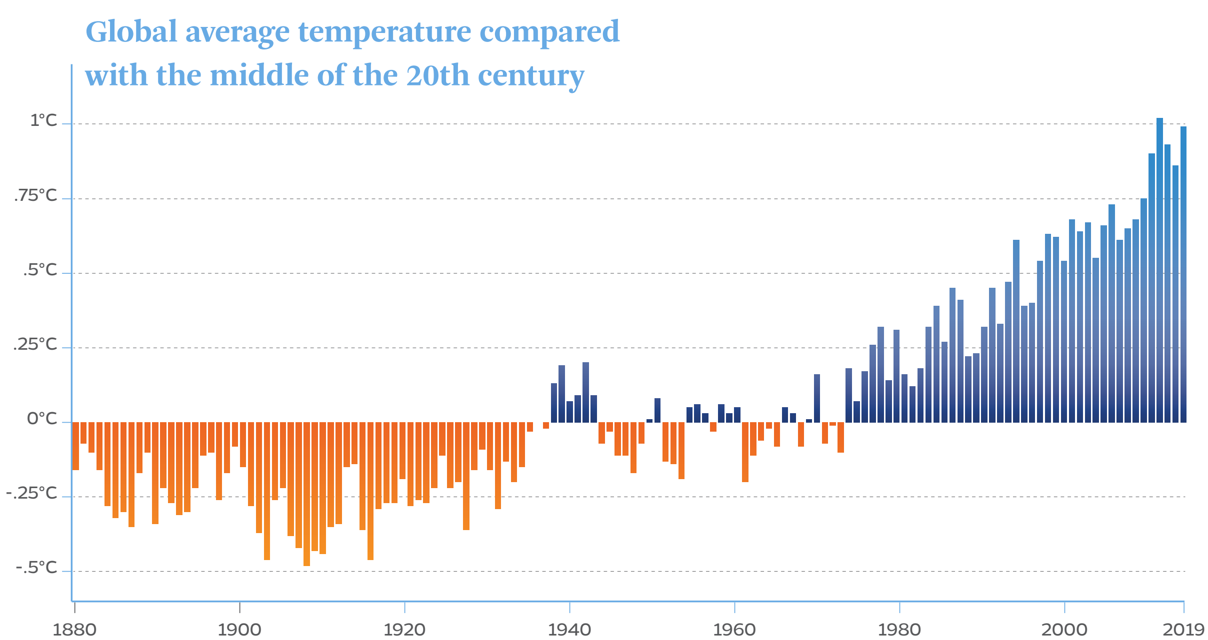
THREATS POSED BY CLIMATE CHANGE

Earth's climate is changing at a rate unprecedented over at least the past thousand years.[2] Although natural variability contributes to the observed changes, scientists overwhelmingly agree that human activities have been the dominant cause of climate change since the mid-20th century. Emissions of greenhouse gases from the burning of fossil fuels and other human actions are trapping heat in the atmosphere, causing the planet to warm.[3]

In its 2014 assessment, the Intergovernmental Panel on Climate Change (IPCC), the scientific body that informs the climate policies of the United Nations' member states, found that each of the past three decades were hotter than any preceding decade since 1850, and that 1983 to 2012 was likely the warmest 30-year period in the Northern Hemisphere over the past 1,400 years.[4] The IPCC concluded that it is "extremely likely" that human activities caused more than half of the increase in global average surface temperature between 1951 and 2010.[5]

More recently, 2019 was one of the hottest years on record, second only to 2016, according to the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA).[6,7] (See Figure 2.) The world's five warmest years have all occurred since 2015, with nine of the 10 warmest years occurring since 2005. This continues a trend that dates back to the 1960s: each decade has been warmer than the previous one.

Figure 2
Global Average Temperatures Have Consistently Risen for Decades



Note: Annual average surface temperatures compared with the average temperature between 1951 and 1980.
Source: National Aeronautics and Space Administration and The New York Times[8,9,10]

Historical temperature records provide some of the clearest evidence of a warming planet, but rising surface temperatures represent only one data point in a larger cascade of Earth system changes. Researchers have documented many other indicators consistent with a warming world, including declining sea ice and snow cover, melting glaciers and ice sheets, rising seas, and more intense extreme weather events, such as hurricanes and wildfires.[11,12] Each trend has important implications for human society; taken together, they pose an existential threat to many millions of people around the world and portend destabilizing disruptions for many more.

The evidence is clear that the climate is changing and that it will continue changing for at least the next century. A certain amount of global warming can no longer be avoided: carbon dioxide and other greenhouse gases can persist in the atmosphere for hundreds of years or longer, and oceans are slowly absorbing the heat trapped by these gases.[13,14] Climate change is, therefore, a manifestation of past actions over decades. Over the past 150 years, atmospheric carbon dioxide has risen from 280 parts per million to more than 400 parts per million, primarily as a result of human activities (e.g., burning fossil fuels for electricity, heat, or transportation); more than a quarter of that increase has occurred since 2005.[15,16,17] Global average temperature rose by about 1.8 degrees Fahrenheit (1.0 degrees Celsius) from 1901 to 2016,[18] and scientists predict that current concentrations of greenhouse gases in the atmosphere will result in at least an additional 1.1 degrees Fahrenheit (0.6 degrees Celsius) of warming over this century.[19]

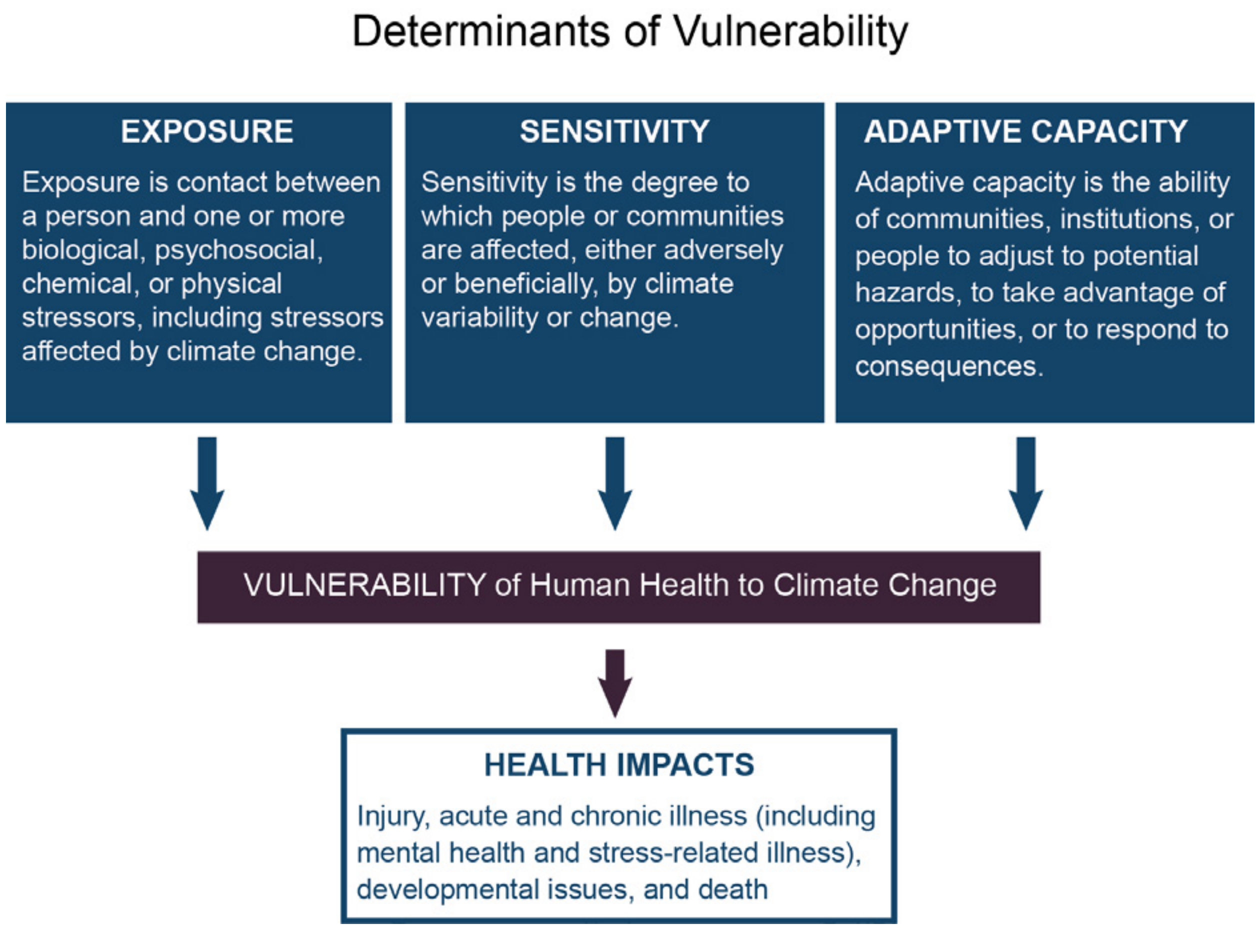
Because the climate system is so complex, the nature of changes beyond 2050 is less certain. Altering any aspect of the land-atmosphere-ocean system can create positive or negative feedback loops; for some aspects, there may be irreversible tipping points—thresholds that, once crossed, move the system out of its stable state.[20] Changes will depend significantly on actions taken over the next decade or two to mitigate greenhouse gas emissions. In the Fourth National Climate Assessment, a major report issued every four years by U.S. federal agencies, the U.S. Global Change Research Program (USGCRP) warned in 2018 that major reductions in emissions are required to limit the global temperature increase to 3.6 degrees Fahrenheit (2 degrees Celsius), compared with preindustrial temperatures.[21] Two degrees Celsius has historically been the international political and scientific consensus target for limiting risks associated with climate change, but a landmark IPCC report in October 2018 warned that even exceeding 1.5 degrees Celsius would produce calamitous effects.[22,23] Absent considerable reductions, annual average temperatures could rise by 9 degrees Fahrenheit (5 degrees Celsius) or more by the end of this century, increasing the severity of future risks, including extreme heat, heavy rains, flooding, wildfires, and drought, as well as the secondary implications for economies, political systems, and health.[24]

While meaningful steps must be taken to reduce future emissions and curtail the warming trend, such actions would only limit the magnitude and intensity of climate change and its impacts; past emissions and technological limitations mean that these impacts cannot be entirely averted. Thus, it is essential that people everywhere prepare to adapt.

> ***Vulnerability is not an intrinsic or static characteristic; it varies over time and place, as well as across life stages. Moreover, in many cases, it is not innate, but rather the result of past and ongoing policies and practices rooted in structural and systemic inequities or discrimination. Therefore, it can be reduced through strategic planning and preparation, as well as through equitable policymaking and investment.***

Climate change will not affect people and places equally. It is a global phenomenon, but its effects are local.[25] Weather patterns vary across regions and over short-term timescales, and their impacts depend in part on the vulnerability of the people affected.[26,27] Vulnerability incorporates place-based exposure to climate-related impacts (e.g., proximity to a coastline), as well as demographic characteristics (e.g., age, socioeconomic status) that shape a person's sensitivity to exposures and their ability to cope.[28] (See Figure 3.) Vulnerability is not an intrinsic or static characteristic; it varies over time and place, as well as across life stages.[29] Moreover, in many cases, it is not innate, but rather the result of past and ongoing policies and practices rooted in structural and systemic inequities or discrimination.[30] Therefore, it can be reduced through strategic planning and preparation, as well as through equitable policymaking and investment.

Figure 3
Exposure, Sensitivity, and Adaptive Capacity Determine Vulnerability



Source: U.S. Global Change Research Program[31]

CLIMATE CHANGE IN THE UNITED STATES

The United States is already experiencing the effects of climate change. From 1901 to 2016, average annual temperature over the contiguous United States increased by about 1.8 degrees Fahrenheit (1.0 degrees Celsius); and recent decades were the warmest in at least 1,500 years.[32] The western half of the country, including Alaska, experienced the largest increases in annual temperature, but warming in the Southeast has accelerated since the 1960s. As a consequence of past emissions, scientists expect the United States to see an additional 2.5 degrees Fahrenheit (1.4 degrees Celsius) increase in annual average temperature by 2050.[33] Much larger increases are projected by the end of the century.

Scientists expect extreme high temperatures to grow more common; that means more frequent and longer-lasting heat waves and more days when the temperature exceeds 90 degrees Fahrenheit. But harmful summer heat is not the only concern; higher winter temperatures are driving some of the country's fastest warming, particularly in the Northeast. Rhode Island has already surpassed the 2 degrees Celsius warming threshold, and Connecticut, Maine, Massachusetts, and New Jersey are close to reaching that unwelcome milestone.[34] In New Jersey, where ice harvesting was once an important industry, the average winter temperature is now above freezing.[35] Over the past century, every region* of the country saw an expansion of its frost-free season. With less snow and ice cover, more solar radiation is absorbed by the ground, rather than reflected back into space, contributing to further warming.[36]

Other indicators of the changing climate display strong regional differences. Since 1901, annual average precipitation increased across the Northeast, the Midwest, and the Northern and Southern Great Plains, and decreased in the Southwest and the Southeast. As with extreme heat, scientists project that the frequency and intensity of heavy precipitation events will multiply, making the kind of flooding that once skipped generations occur every few years.[37]

In parts of the United States, extreme weather events are becoming commonplace. Western states, particularly California, have experienced record-breaking droughts and high temperatures, coupled with ruinous wildfires and mudslides. At least three-quarters of California's 20 most destructive fires—measured by the number of structures destroyed—have happened since 2015.[38] Unusually powerful hurricanes have plagued the Caribbean, the Southeast, and Texas, with Hurricane Harvey dumping four feet of rain on Houston and Hurricane Maria devastating Puerto Rico in 2017.[39,40] Although it is difficult to attribute any single event to climate change, scientists are increasingly confident of its link to the greater frequency and intensity of these extreme events.[41,42]

* This report applies the regional designations defined by the U.S. Global Change Research Program. **Alaska**: Alaska; **Hawaii and U.S.-Affiliated Pacific Islands:** Hawaii. **Midwest:** Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. **Northeast:** Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. **Northern Great Plains**: Montana, Nebraska, North Dakota, South Dakota, and Wyoming. **Northwest:** Idaho, Oregon, and Washington. **Southeast:** Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. **Southern Great Plains:** Kansas, Oklahoma, and Texas. **Southwest:** Arizona, California, Colorado, Nevada, New Mexico, and Utah. Territories located in the U.S. Caribbean region were not included in the study, owing to a lack of comparable data.

Health impacts of climate change in the United States

Extreme events such as hurricanes and wildfires pose a clear threat to human health and safety. Other health impacts of climate change are less apparent, but no less important. Many health outcomes are linked to environmental factors and, as such, are sensitive to changes in climate and weather. These changes affect human health through a variety of pathways. Climate variables such as temperature and precipitation, for example, can act directly as stressors on human health; they can also create conditions that give rise to other health threats, such as infectious diseases or changes in air and water quality.

The U.S. federal government has identified seven categories of climate-related health impacts:[43]

1) ***Temperature-related death and illness.*** Temperatures that are above seasonal averages make it difficult for the human body to cool itself, leading to illnesses such as heat cramps, heat exhaustion, heatstroke, and hyperthermia. Scientists expect climate change to increase temperature averages and extremes, resulting in an increase in illness and death. Researchers expect reductions in cold-related mortality to be offset by increases in heat-related mortality.

2) ***Air quality impacts.*** Airborne pollutants and allergens in both indoor and outdoor environments harm the human respiratory and cardiovascular systems. Changing weather patterns will favor the formation of ground-level ozone over much of the United States. Wildfires emit fine particulate matter and ozone precursors that can worsen air quality for hundreds of miles.[44] In 2017 and 2018, Seattle saw 24 days of increased air pollution, stemming from wildfires in Washington and surrounding states, including four days in 2018, when the air quality was rated "unhealthy for all."[45,46] Increasing levels of carbon dioxide and warmer temperatures also promote plant growth, leading to higher pollen concentrations and longer growing seasons, which may contribute to a rise in the number of asthma episodes and allergic illnesses.

3) ***Impacts of extreme events on human health.*** Extreme events such as hurricanes, floods, wildfires, and other major storms can directly cause injury and death. They may also disrupt essential infrastructure (e.g., electricity, water, transportation, communication systems) in ways that can limit access to healthcare and emergency response services and can reduce the availability, quality, and safety of food, water, and medications.[47,48] In Texas's Harris County, encompassing Houston, historic rains from Hurricane Harvey in August 2017 severely restricted and delayed emergency rescues; volunteers with boats and high-water vehicles helped transport residents who needed medical care to hospitals that were struggling to manage amid their own flooding.[49,50] Months after the deadly Camp Fire in Paradise, California, in 2018, experts still advised residents not to drink or cook with the water due to concerns about benzene contamination.[51,52]

4) ***Vector-borne diseases.*** Some diseases spread from person to person (or animal to person) by way of a third organism, or "vector," such as a mosquito or a tick. Changes in environmental conditions that affect the prevalence, distribution, and activity of vectors also affect when, where, and how often humans get sick. As temperatures increase and frost-free seasons grow, ticks that carry Lyme disease and other human pathogens will likely continue to expand their geographic and seasonal distribution in the United States. Warmer and, in some places, wetter conditions may well also increase the abundance and range of mosquitoes that carry West Nile virus, Zika virus, and other pathogens.

5) ***Water-related illness.*** Changes in temperature and precipitation can affect the growth, survival, spread, virulence/toxicity, and seasonality of waterborne bacteria, viruses, and toxic algae that directly or indirectly cause illness in humans. Greater precipitation and extreme weather events may also lead to contamination of drinking and recreational water sources through increased runoff or infrastructure failures. Contaminants could include sewage or chemicals from human activities. Following Hurricane Maria in 2017, researchers from the University of Miami found elevated levels of polychlorinated biphenyls—a group of human-made organic chemicals that are thought to cause cancer and other ailments—in both the soil and in the people of Guánica, Puerto Rico.[53] In the immediate aftermath, the territory saw an increase in infectious diseases, including the normally rare bacterial disease leptospirosis.[54]

6) ***Food safety, nutrition, and distribution.*** In addition to disruptions in food supply caused by drought, flooding, and other extreme events, warming temperatures and changes in other environmental conditions are changing the prevalence and distribution of pests, pathogens, and food species, both on land and at sea, with health and economic consequences. Shorter and milder winters have given a boost to invasive fruit flies that threaten tart cherries in Michigan, raspberries in New York, and blueberries in Maine.[55] In the Northeast, warming seas have shifted the lobster population northward—a temporary boon for fisheries in Maine and a catastrophe for those in Rhode Island.[56,57] Warming waters off the coast of Alaska are making shellfish toxic, endangering the lives and livelihoods of Alaska Natives.[58] Scientists even expect climate change to alter the nutritional profile of some foods: higher concentrations of carbon dioxide can increase carbohydrate production, while also lowering levels of protein and other essential minerals in staple crops, such as wheat, rice, and potatoes.

7) ***Mental health and well-being.*** Exposure to climate-related disasters can produce stress and mental health disorders such as depression, anxiety, and post-traumatic stress disorder. In the months following Hurricane Katrina in 2005, calls to crisis helplines increased by 61 percent.[59] Higher rates of behavioral health disorders persisted for years.[60] Repeated exposure to disasters, as is expected in a warmer world, is also a risk factor.[61] People may also experience chronic stress from the gradual impacts of climate change, and they may experience other mental health outcomes based on related threats and perceived experience.[62] Other climate-related health outcomes can also contribute to a decline in mental health. People with existing mental illness face an especially acute threat from extreme heat, which increases their risk of both physical illness and death.[63,64]

Each of these categories represents known and, in many cases, longstanding threats to human health. That is, climate change exacerbates existing threats through increased frequency, duration, and intensity of exposure. It also shifts or expands the locations of exposures, introducing threats to populations that were not previously at risk.

While science's understanding of how climate change affects health has grown significantly in recent years, the ability to model health outcomes with precision remains limited, and it differs across climate impacts and health outcomes based in part on data availability.[65] Rather than generating pinpoint estimates, models provide insights about "how systems work and what may happen in a particular set of conditions" that can guide decision-making.[66] Many health impacts of climate change operate through indirect pathways that can be hard to quantify and predict. Because of this complexity, scientists are not yet always able to model outcomes such as disease incidence, injury, or mortality. In some cases, they instead examine how climate change might affect an exposure or an intermediate health determinant and use that as a signal of how health risks may change.[67] For example, most analyses of vector-borne disease have projected changes in season length or range expansion, rather than in infection rates.[68]

To inform USGCRP's Fourth National Climate Assessment, the Climate Change Impacts and Risk Analysis (CIRA) project, coordinated by the U.S. Environmental Protection Agency (EPA), sought to quantify some potential health effects.[69] One analysis looked at how changes in temperature under two emissions scenarios would affect the disease burden of West Nile neuroinvasive disease in the contiguous United States. CIRA projected that annual cases would more than double by 2050, compared with 1995, when the country saw just under 1,000 cases. By the end of the century, annual cases would increase by thousands more.[70] These figures are almost certainly underestimations, owing to gaps in available data.

Even relatively straightforward exposure-disease relationships pose challenges. Temperature-related illness is perhaps the most direct pathway to model, but even it can be challenging to parse using available data. For example, extreme heat exposure can lead to numerous health outcomes, and temperature may not always be reported as a cause of the morbidity or mortality.[71,72] Furthermore, the effects of temperature are different across regions and seasons, as well as population groups.[73] In its 2016 Climate and Health Assessment, USGCRP projected that temperature exposure will increase mortality on the order of thousands to tens of thousands of premature deaths each year by the end of this century.[74]

Some of the challenge of projecting the health burden of climate change is a consequence of the uncertainty of climate forecasts. Accurate predictions of health impacts—inherently local—require downscaled climate projections, which are not always available for the area of interest. The global picture matters, too: ultimately, health risks will depend in part on the scale of greenhouse gas emissions in places halfway around the world over the next decade and beyond.

Under a relatively high-emissions scenario, changes in temperature in 49 U.S. cities (accounting for about one-third of the country's population) could contribute to over 9,000 additional premature deaths each year by 2090; under a lower-emissions scenario, nearly 60 percent of those deaths could be avoided.[75,76] Extreme temperatures could result in net mortality rates of greater than eight deaths per 100,000 residents in nearly every city outside the Northwest in 2090.[77] These estimates do not account for changes in morbidity, although that burden is likely to be significant.

Human behavior shapes the trajectory of climate-related health impacts at a more local level, as well. Actual health outcomes depend not only on the environmental hazard, but on whether individuals and communities can avoid exposure to it or otherwise reduce its danger. Building adaptive capacity can change the relationship between a hazard and health outcomes. In the words of the USGCRP, "Climate change impacts can either be amplified or reduced by individual, community, and societal decisions."[80] For example, although temperatures have risen over the past century and particularly since 1970, the protective effect of air conditioning and other improvements have more than offset any rise in heat-related illness.[81]

We know with greater certainty that climate change in the United States will affect the health of some communities or people more than others. Some are more vulnerable because of age (e.g., children, older adults) or preexisting medical conditions (e.g., diabetes, asthma). People who work outdoors or as first responders may face greater exposure. Large portions of other groups, such as immigrants, people of color, and people living in poverty, may have less access to resources that would allow them to avoid exposures, seek care or treatment, or navigate long-term recovery, such as rebuilding after a fire or flood. Communities with fewer resources may be unable to meet demand for services like cooling centers, even as they suffer from greater sun exposure without the natural protection afforded to wealthier communities with more extensive tree canopies, a difference with historical ties to discriminatory housing policies such as "redlining."[82,83] In many cases, vulnerability to the health impacts of climate change reflects and exacerbates preexisting health risk factors and disparities.[84]

A CALL FOR HEALTH EQUITY AND ENVIRONMENTAL JUSTICE

Systemic racism in the United States undermines equity and opportunity, inflicting a far-reaching toll on the lives and health of Black people and other people of color. Its cross-cutting impacts are felt across health, education, economic opportunity, employment, housing, transportation, criminal justice, and other social determinants of health. And they are felt through environmental conditions, such as pollution sources regularly located near communities of color, and, indeed, climate change itself.[78] This is one reason why the two groups of Americans who care most about climate change are Latinx Americans and Black Americans.[79]

It is a regrettable axiom that people of color in the United States suffer from health threats first and worst. This was true once again with COVID-19, and it will continue to be true of climate change, unless leaders at all levels and across sectors prioritize the protection of disadvantaged people, including by finally confronting and reconciling with centuries-old biases that sit at the core of so many socially determined disparities. It is long past time to advance health equity and environmental justice.

In addition to its direct effects on human health, climate change may also produce disruptions to healthcare, social services, and other systems that are critical to a community's ability to manage or respond to health needs. This threat is particularly evident with natural disasters, which often destroy infrastructure, disrupt power and water supplies, and require a large-scale response. Even a prolonged heat wave or an extremely hot day may overwhelm power grids as people rely more heavily on fans and air conditioners. Such disruptions have a disproportionate impact on people with existing health conditions who require daily medication or treatment (e.g., dialysis), who have limited mobility, or who are more sensitive to climate-related exposures, such as high temperatures or poor air quality. Many medications and life-saving medical devices require a stable supply of electricity. People who lack reliable transportation or financial resources may find it more difficult to access services elsewhere in the event of a disruption.

Actions to mitigate climate change can also have direct health implications. For example, shifting from fossil fuels toward renewable energy sources such as solar or wind power reduces emissions, resulting in cleaner air and a subsequent reduction in the disease burden related to air pollution.[85,86] On an individual level, there is growing evidence that shifting to a plant-based diet or to more active modes of transportation (e.g., walking, biking, etc.) can promote better health outcomes.[87] Understanding potential health co-benefits can inform public health planning and policy decisions about mitigation and adaptation investments.[88]

PREPAREDNESS AND EMERGENCY MANAGEMENT IN THE UNITED STATES

As climate change increases the frequency, severity, and duration of weather-related health emergencies, communities around the world must prepare to minimize adverse impacts. They must be ready to prevent, respond to, and recover from incidents that pose public health risks. This is a key aspect of a broader preparedness regime capable of addressing natural hazards and manmade threats.[89]

In the United States, multiple actors at all levels of government share responsibility for preparedness and emergency management. Under this tiered system, action begins at the local level and expands to the state, territorial, tribal, regional, and federal levels as greater resources and capabilities are required.[90] If one tier's resources are overwhelmed, the tier above it is engaged to provide support. Strong coordination of all stakeholders is essential. Each group must be aware of its roles and responsibilities, as well as how it fits into the larger framework.

The U.S. Department of Homeland Security and the U.S. Department of Health and Human Services serve as focal points for federal emergency management and health security, coordinating preparedness efforts nationally.[91] The National Preparedness System guides these efforts and organizes them around a continuum of five interrelated mission areas: (1) prevention, (2) protection, (3) mitigation, (4) response, and (5) recovery.[92,93]

Within each mission area, the National Preparedness System identifies core capabilities for dealing with hazards.[94] The system reflects a layered approach that integrates shared responsibilities horizontally (across departments and agencies) and vertically (across all levels of government).[95] The federal government provides guidance and other resources to support its agencies, states, territories, tribes, and local jurisdictions in building their preparedness capacity.

The system is built around a whole-community approach to planning and implementing preparedness efforts; "whole community" refers to individuals and families, including those with access and functional needs; schools and academic institutions; faith-based and community organizations; businesses; nonprofits; media outlets; and all levels of government.[96,97] This approach is intended to help each group know its roles and responsibilities so that all stakeholders work well together. It also allows public officials to better understand a community's needs and capabilities, and plan accordingly.[98] Thus, it is critical that vulnerable populations be regularly engaged and that they inform planning. Ensuring government hears and acts on the perspectives of these individuals or communities can improve their outcomes in the event of an emergency.

In most cases, the local community or tribe is the first to prepare or respond.[99,100] Many incidents are managed entirely by the affected community and local leadership.[101] If the demands of preparation or response surpass local resources or capabilities, the state or territory may step in to supplement the efforts of the local government and, if necessary, coordinate with neighboring states.[102] The federal government can also get involved, providing funding, resources, or technical assistance and field support.[103] Typically, this happens when the governor of a state or territory or the chief executive of a tribe requests federal assistance. Federal resources may also be activated by a presidential emergency declaration or when the federal government has jurisdiction based on the subject matter or location of the incident.[104] The National Response Framework sums up this tiered approach as: “federally supported, state managed, locally executed.”[105]

ADDRESSING THE IMPACTS OF CLIMATE CHANGE IN THE UNITED STATES

Within the National Preparedness System, the federal government has acknowledged the potential for climate change to alter communities’ exposures and vulnerabilities to certain hazards.[106,107] The increasing frequency, intensity, and severity of climate change-related incidents is likely to overwhelm state and local resources more often, requiring more frequent activation at the federal and state levels.

Governments may have to deal with multiple incidents or disasters simultaneously. This has become a defining feature of the wildfire season in California and other western states, placing a strain on both local and national response systems. By July 2018—one month into its fiscal year—California had already spent about one-quarter of its emergency fire-suppression budget.[108] This is also becoming true of tropical storms. The 2017 hurricane season was the first one in which the United States experienced three Category 4 or greater hurricanes; parts of Texas, Florida, Louisiana, Puerto Rico, and the U.S. Virgin Islands are still dealing with the devastation wrought by Hurricanes Harvey, Irma, and Maria over the span of just two months.[109] Between 2016 and 2019, Harris County, Texas—the nation’s third-most populous county[110]—experienced one 500-year rainfall event and two 100-year rainfall events.[111] Such frequency and intensity does not give communities time to recover or rebuild, leaving them more vulnerable when the next storm hits.

States and other jurisdictions are also likely to face new or less familiar threats. Climate change is shifting and expanding the geographic and seasonal risk of some hazards. Many of the dangers of climate change are insidious, lacking a singular event or clear catastrophe. Cities in the Southwest, already plagued by triple-digit summer temperatures, have seen a sharp increase in heat-related mortality in recent years as average temperatures—both daytime highs and nighttime lows—have risen. From 2014 to 2017, deaths related to heat exposure more than tripled in Arizona; most of these deaths were in the Phoenix area.[112] Older people and those who experience homelessness are particularly vulnerable, as are low-income and predominantly Latinx neighborhoods that lack shade and other cooling features.[113] Indeed, patchy tree cover in poor urban neighborhoods, predominantly communities of color, is a pervasive problem throughout

the United States, resulting from a mix of development, natural disasters, disease, invasive species, and a lack of resources for tree care and restoration.[114]

Recognizing that climate change does not affect all people or communities equally and addressing these differences is critical to limiting the impact of climate-related hazards. Preparedness activities offer an opportunity to think ahead about how to protect vulnerable populations across a state or local jurisdiction.

Americans broadly support action. According to an April 2020 study by the Yale Program on Climate Change Communication and the Center for Climate Change Communication at George Mason University, two in three Americans are at least "somewhat worried" about global warming.[115] More than four in 10 think global warming will harm them, and even more think it will harm their family and people in their community. Many Americans—indeed, about double the share from 2014—think a variety of negative physical and psychological outcomes harms will become more common in their community because of global warming over the next 10 years, if nothing is done to address it.[116] And a majority thinks state and local governments should place a "high priority" on protecting people's health from the effects of global warming over the next 10 years.

Mitigation and adaptation

The policy response to climate change falls into two major categories: (1) mitigation and (2) adaptation. Mitigation refers to actions that slow down or reduce the magnitude of climate change, primarily by reducing emissions of greenhouse gases or removing such gases from the atmosphere. Adaptation refers to the process of adjusting to the effects of actual or expected climate change by making decisions or investments to counter specific risks.[117,118] The global IPCC and the USGCRP's Fourth National Climate Assessment both stress that mitigation and adaptation are complementary strategies, each essential to minimizing the human impacts of climate change.

Both mitigation and adaptation can reduce injuries, illnesses, and deaths from climate-related health outcomes, but there are differences related to how quickly and locally some benefits may be realized. Much of mitigation operates over a longer time horizon to reduce future risks, while adaptation focuses on limiting the risk and impact of changes that are already underway, fueled by past greenhouse gas emissions.[119] Adaptation is grounded in the recognition that, based on past emissions, some level of climate change is inevitable, and people must prepare to live in a changing environment.[120] Its benefits are more immediate than much of those of mitigation. The risks posed by climate change are context- and place-specific, so adaptation takes place primarily at the state and local level.[121,122] Because adaptation focuses on addressing specific risks, interventions can be directed toward reducing vulnerabilities and increasing the resilience of specific groups or communities. Many of the benefits of mitigation actions are more diffuse, accruing globally instead of locally, though some—improved health owed to safer air quality or more active modes of transportation—materialize more swiftly for the communities engaged in them and can reduce related inequities.[123]

Adaptive actions are meant to manage climate-related risks, which are driven by exposure and sensitivity to hazards. The greater the adaptive capacity and follow-through—among individuals, businesses, governments, and other sectors—the lower the risk. With respect to health impacts, adaptation involves assessing vulnerabilities of a location or community to specific threats (e.g., extreme heat, flooding, vector-borne diseases), identifying evidence-based interventions, developing and implementing a plan, and then monitoring and evaluating the interventions to pinpoint and address weaknesses. The Centers for Disease Control and Prevention (CDC), through its Climate and Health Program, provides a step-by-step guide for governments and others to follow.[124]

There are numerous approaches to address the most pressing threats. For example, to help protect people from extreme heat, an area might employ a mix of early warnings, cooling shelters, and an expansion of green spaces. To combat West Nile virus and other mosquito-borne infections, a community might look to destroy breeding sites. Localities might employ crisis-counseling services to people whose mental health has been harmed by a traumatic disaster.

Climate-related adaptation, a vital element of public health preparedness efforts, is the focus of this report.[125]

COVID-19 IMPAIRS PREPAREDNESS AND EMERGENCY RESPONSE

The COVID-19 pandemic has strained U.S. emergency response systems at all levels, revealing critical health security weaknesses and exposing the nation's longstanding systemic inequities. These weaknesses affect not only the country's ability to limit the spread and impact of SARS-CoV-2, but also its resilience to climate change in both the short and long term.

As the nation grapples with the pandemic, it has also had to prepare for and respond to weather-related emergencies and natural disasters. Climate change is already increasing the frequency and intensity of heat waves, droughts, storms, and wildfires.[126] At the time of writing, the nation was in the midst of multiple record-setting disaster seasons. As NOAA predicted in spring 2020, the Atlantic hurricane season has been well above-average,[127] while a dry winter combined with an unusually hot and dry summer contributed to the most active fire season in the West on record.[128]

Protecting communities from these growing threats—already a challenge—has been further complicated by the pandemic. The COVID-19 response requires significant resources—money, staff, equipment, and supplies. Yet, resources at all levels—federal, state, and local—were already stretched thin. To support a nationwide pandemic response, the Federal Emergency Management Agency (FEMA) redirected resources from emergency response and training, reducing its available trained personnel, even as staff shortages had already been a struggle during recent severe weather seasons.[129,130] Worse, experts were expecting fewer disaster response volunteers, owing to the risk of COVID-19.[131]

Just as emergency response agencies need more resources, sharp declines in tax revenue brought on by pandemic-related economic shutdowns have created huge gaps in state budgets. In January 2020, California announced $100 million in state and federal funding to support home retrofits to make structures more fire-resistant, with a particular focus on low-income communities.[132] But facing a sudden budget deficit, the governor proposed suspending the program, as well as plans for a Climate Resilience Bond and other funding for climate-related projects. Around the country, climate-related capital projects, such as sea walls and raised roads, face a similar fate.[133,134] Delays related to the pandemic have also threatened states' ability to meet the conditions for federal funding under a program to support model climate-resilient construction projects.[135]

States must also balance the need to protect residents from competing hazards. Some measures required to protect people from a hurricane or wildfire—evacuation and shelter, for instance—are at odds with those used to mitigate the spread of infections. Under new hurricane preparedness guidelines, FEMA encourages states to use non-congregate shelters such as school dormitories or hotels,[136] making it more difficult to meet capacity needs. Additionally, adhering to physical distancing has changed the way emergency personnel respond to disasters. In states facing wildfires, officials have had to introduce new precautions, such as breaking firefighters into smaller units.[137]

Addressing the needs of acutely vulnerable populations—many of whom are also bearing a disproportionate burden from COVID-19—has been especially challenging. Struggling households have fewer resources to prepare for emergencies and rely heavily on states for relief aid. Many communities count on cooling centers for protection during extreme heat events, but physical-distancing restrictions limit the number of people who can be safely accommodated. And fear of infection may prevent some from seeking shelter.

The pandemic has revealed weaknesses in the nation's health security systems. But other emergencies will not stop for the pandemic, so state and federal agencies must take extra precautions to prepare the nation, even as they work to prevent the spread of COVID-19.

AN ASSESSMENT OF STATE CLIMATE-RELATED VULNERABILITY AND PREPAREDNESS

While climate change is impacting virtually every corner of the planet, the nature and degree of risks vary by place and community, as does readiness for protecting people. Indeed, there is an interdependent relationship between vulnerability and readiness. The more at risk an area is, the greater lengths it ought to go to prepare.

This principle applies to every country, and it applies to every U.S. state. Some states will face unforgiving rising seas and record-breaking hurricanes, while others will grapple with unprecedented wildfires and drought. The steady creep of riverine flooding will halt daily activities in some places, while disease-carrying vectors will creep into others. And the demographic characteristics that so heavily influence people's adaptive capacities differ in significant ways among and within states.

This variability, and other distinctive contexts of states and their residents, will necessitate that each state develop its own set of solutions to the challenges that climate change presents. But the planning process is essentially the same, beginning with an in-depth examination of risks and vulnerabilities, and then rigorously searching for interventions that are most likely to succeed.

To better understand the threats posed to states, and the extent of their preparations, researchers at Trust for America's Health and the Johns Hopkins Bloomberg School of Public Health studied the circumstances of every state and the District of Columbia.* (American Indian and Alaska Native tribal nations and U.S. territories were not included in the assessment, owing to a lack of comparable data, a serious gap that this country must work to fill given the acute threat that climate change poses to many of their residents.) The analysis employed a set of quantitative indicators spanning three domains of inquiry: (1) vulnerability; (2) public health preparedness; and (3) climate-related adaptation. The results provide a portrait of state-level preparedness for the public health impacts of climate change in the United States.

A review of academic and grey literature, as well as a series of structured interviews with issue experts, informed this framework of domains and indicators. Researchers closely examined more than 200 academic articles (starting from a universe of 4,000)—primarily focused on the vulnerability of discrete places—and published work by leading bodies, including the USGCRP, the CDC, and the American Public Health Association. They also spoke with a diverse group of experienced colleagues about essential elements of preparedness and the factors they depend on; best practices in the area of climate-related adaptation and how those practices are facilitated or impeded; and states or localities that are seen as leaders in this area.

* The District of Columbia was treated as a state in this study. Any reference to states generally should be understood to include the District.

States are the focus of this study because they play a central role in coordinating funding and planning, but local partners play an essential and, in some places, a leading role in putting relevant preparations into motion. State efforts are most successful when they operate in close collaboration with frontline communities. While this assessment does not directly capture local actions, researchers appreciate their importance.

Every state has a strong interest—put in stark relief by the COVID-19 pandemic—in building and maintaining a robust public health system equipped to promote health, safety, and well-being. This is the responsibility of not just public health officials, but also elected leaders and partner agencies. Certainly, every state has skilled, dedicated staff working to protect as many people as possible. But chronic underfunding and other obstacles have left room for improvement everywhere—a lot of room in some states—particularly across system elements that are most pertinent to preparedness for weather-related emergencies.[138]

Likewise, a wide range separates states with respect to basic preparations for adapting to climate change's health impacts. Some have invested real time and resources for years, including by establishing dedicated teams that continuously work to hone a detailed understanding of their state's climate-related threats and evidence-based interventions. Others, including some with higher vulnerabilities and risks, seem to have barely begun.

The following analysis lays out where states stand across the three domains and highlights lessons and examples with broad relevance.

TOPLINE FINDINGS OF THE ASSESSMENT

To help advance a comprehensive understanding of states' recent positioning vis-à-vis the health impacts of climate change, researchers, after thoroughly reviewing published literature and consulting with subject-matter experts, targeted three essential underlying elements—(1) vulnerability, (2) public health preparedness, and (3) climate-related adaptation—and rigorously selected indicators to measure them. (See Table 2.) Individually, each indicator sheds light on an important aspect of states' risk and readiness; collectively, and by juxtaposing them, they illuminate a fuller landscape than has been available to date.

Table 2

Indicators of Readiness to Confront Health Impacts of Climate Change

VULNERABILITY	PREPAREDNESS	
Domain 1: Vulnerability	**Domain 2: Public health preparedness**	**Domain 3: Climate-related adaptation**
Environmental factors		**Vulnerability assessment**
Extreme heat	Health surveillance and epidemiological investigation	Have climate-related exposures been identified?
Flooding	Environmental monitoring	Have climate-sensitive health outcomes been identified?
Drought	Incident management	Have risk factors for health outcomes been identified?
Wildfire	Information management	Have causal pathways of climate-related hazards been developed?
Severe storms	Cross-sector / community collaboration	Have climate projections been reported?
Disease vectors	Social capital and cohesion	Have vulnerable populations been identified and located?
Social and demographic factors	Prehospital care	**Intervention identification**
Poverty	Long-term care	Have interventions been identified?
Income inequality	Hospital and physician services	Were the interventions evidence-based?
Age composition	Behavioral healthcare	
Race/ethnicity composition	Home care	
Disability		
Housing		
Transportation		
Language proficiency		
Education level		

Note: See "Appendix A: Methodology" for a full description of indicators.

Researchers scored the measures and grouped states, first by level of vulnerability (Domain 1) and then by level of preparedness (Domains 2 and 3). (See "Appendix A: Methodology" for a full description of indicators and how scores were calculated.) The results provide stakeholders seeking to stratify states and target those at highest risk and/or in greatest need of improvement with critical context. More importantly, they help leaders at the state and local level better understand their risk and readiness.

There are clear regional distinctions with respect to states' relative vulnerability. (See Table 3.) All but five (Arizona, California, Missouri, New Mexico, and West Virginia) of the 17 states classified as "most vulnerable" are in the Southeast or the Southern Great Plains. In fact, all but two states in these two regions (Kansas and Virginia) were within this group, with Florida, Arkansas, Louisiana, South Carolina, Mississippi, and Kentucky found to be the most vulnerable in the country. By contrast, states that were "least vulnerable" are located throughout the country, with a slight predominance of those from the Northeast or Northern Great Plains.

Regional differences in preparedness were also fairly stark: a clear majority of the states found to be "most prepared" are in the Northeast, and a plurality of states found to be "least prepared" are in the Southeast. The most prepared states in the country were Utah, Maryland, Vermont, Virginia, Colorado, and Massachusetts, while the least prepared states were West Virginia, Mississippi, Oklahoma, South Dakota, and Wyoming.

Of cause for concern, a number of states with high levels of vulnerability were among the least prepared in the country.

Of cause for concern, a number of states with high levels of vulnerability were among the least prepared in the country. Indeed, researchers found a moderately negative correlation (correlation coefficient: -0.35) between vulnerability and preparedness. That is, the more vulnerable states were, the less prepared they tended to be—the opposite of what would be in the best interest of states and residents facing the most dangerous impacts. Just two states (Arizona and North Carolina) that were rated "most vulnerable" were also rated "most prepared." All except four states (California, Missouri, New Mexico, and West Virginia) that were classified as "most vulnerable" but *not* "most prepared" are in the Southeast or the Southern Great Plains.

While this stratified analysis is instructive for understanding the extent of states' preparedness within the context of their vulnerabilities, it is essential to also parse the data underlying these results. The following sections discuss and analyze each domain of indicators in detail, highlighting states that stand out as leaders and potential models for their peers.

Table 3

States Grouped by Level of Vulnerability and Preparedness

Vulnerability Group	State	Vulnerability Score Least Vulnerable: 3.4-4.7 More Vulnerable: 4.8-5.3 Most Vulnerable: 5.4-6.3	Preparedness Score Least Prepared: 4.0-5.0 More Prepared: 5.1-5.8 Most Prepared: 5.9-6.6
Least Vulnerable	Utah	3.8	6.6
	Maryland	4.4	6.3
	Vermont	4.3	6.3
	Colorado	4.0	6.2
	Wisconsin	4.4	6.1
	New Hampshire	4.1	6.0
	District of Columbia	4.5	5.9
	Maine	4.5	5.9
	Minnesota	4.4	5.8
	Washington	4.5	5.8
	Michigan	4.7	5.8
	Alaska	3.4	5.4
	North Dakota	4.1	5.2
	Nebraska	4.6	5.1
	Idaho	4.2	5.0
	Montana	4.3	4.8
	Wyoming	4.2	4.5
More Vulnerable	Virginia	4.8	6.3
	Massachusetts	4.9	6.2
	Rhode Island	4.9	6.0
	Illinois	4.9	6.0
	New York	5.3	5.9
	Pennsylvania	5.3	5.9
	Connecticut	4.9	5.9
	Oregon	4.8	5.8
	Delaware	4.9	5.7
	Kansas	5.1	5.3
	Iowa	4.9	5.3
	Indiana	5.0	5.0
	Ohio	5.1	5.0
	New Jersey	5.2	4.9
	Hawaii	5.3	4.8
	Nevada	4.9	4.6
	South Dakota	4.8	4.5
Most Vulnerable	North Carolina	5.5	6.0
	Arizona	5.4	5.9
	Alabama	5.8	5.8
	California	5.5	5.8
	Louisiana	5.9	5.7
	New Mexico	5.8	5.7
	Arkansas	6.1	5.5
	Missouri	5.4	5.5
	Florida	6.3	5.1
	Tennessee	5.5	4.9
	Georgia	5.6	4.9
	Kentucky	5.9	4.8
	South Carolina	5.9	4.8
	Texas	5.5	4.6
	Mississippi	5.9	4.5
	Oklahoma	5.5	4.5
	West Virginia	5.8	4.0

"Most prepared," among states that were "least vulnerable."

"Least prepared," among states that were "least vulnerable."

Note: To group states, researchers first rank-ordered them by vulnerability score, producing three groups of 17: "least vulnerable," "more vulnerable," and "most vulnerable." Separately, researchers rank-ordered states by their preparedness score—an unweighted average of their scores for Domain 2 and Domain 3, producing three groups of 17: "least prepared," "more prepared," "most prepared." The latter grouping determined the preparedness classifications of states within vulnerability categories. Within each category of vulnerability, states highlighted in turquoise are "most prepared," states highlighted in yellow are "more prepared," and states highlighted in red are "least prepared." The "border" between groupings may not yield significantly different scores. Readers should look at the actual scores provided in this report for a full understanding of each state's situation. See "Appendix A: Methodology" for a full description of indicators and how scores were calculated.

DOMAIN 1: VULNERABILITY

Vulnerability: the degree to which physical, biological, and socioeconomic systems are susceptible to and unable to cope with the adverse impacts of climate change.

Source: U.S. Global Change Research Program[139]

Climate change is a global phenomenon, touching all life on Earth. Every place will experience its effects, but not in the same way or to the same degree. The global trends discussed above are manifested through local weather patterns and environmental changes. Where a person lives will, in large part, drive her experience of climate change.

Even within a single place, however, individuals and communities may experience climate change in starkly different ways. Differences in exposure, sensitivity, and adaptive capacity mean that some people are more vulnerable to the health impacts of climate change than other people—that is, they are more susceptible to and less able to cope with these impacts.[140]

Some aspects of vulnerability are innate (e.g., age, some health conditions, disabilities). Intrinsic biological differences shape sensitivity to exposures, making some people more likely to get sick or experience a severe course of disease. But many other factors are important for health because they reflect social or economic conditions—often, patterns of deprivation and discrimination—that have meaningful health impacts. Some experts have argued that so-called natural disasters are, in fact, rarely natural; rather, “it is the social, political, and economic context that makes an environmental hazard become a disaster.”[141] Even “geography is never an accident.”[142]

In the United States, the legacy of colonization, slavery, and ongoing structural and systemic racism contributes to significant health disparities between white and nonwhite populations and, in particular, between white and Black and white and Native American populations. These disparities manifest in myriad ways, including less access to quality healthcare, transportation, housing, and food; greater exposure to polluted air, water, and soil; and resulting chronic stress and higher rates of chronic health conditions such as diabetes, asthma, and cardiovascular disease.[143] As examples, Black and Latinx communities are exposed to more air pollution than they produce—white Americans experience the opposite—and more than 30 percent of Black New Orleanians did not own cars when Hurricane Katrina swept ashore, making evacuation all but impossible. Socioeconomic characteristics (e.g., poverty, income inequality, education level) also affect the ability of individuals and communities to prepare for and cope with health emergencies or adverse events, in part because they determine access to resources and information.[144,145,146]

California's record-breaking, catastrophic wildfires have affected people across the socioeconomic spectrum, but the devastation is not equally distributed.[147,148] For some wealthier residents, losing their home in the 2017 Wine Country fires presented an opportunity to rebuild better with the aid of savings or insurance payouts.[149] Low-income residents and communities have not shared this experience. A year after the Camp Fire destroyed more than 11,000 houses in Paradise, California, only 11 had been rebuilt.[150] People who are poor are less likely to have robust insurance coverage; they may also face more obstacles to obtaining aid.[151] Together, differences in exposure, sensitivity, and adaptive capacity determine the likelihood that climate change will harm the health status of a person or community. This is also true at the national level: some states are more vulnerable than others by virtue of location, demographics, or both. Understanding these differences is essential to understanding how prepared each state is. Preparedness must be measured against the real risks a state faces, as well as the ability of its people to cope with those risks. A state that is more vulnerable will need to go to greater lengths to adequately protect its population from climate-related health impacts, including through dedicated work to ameliorate societally imposed sensitivities.

Measuring vulnerability

To assess the vulnerability of each state, researchers developed a set of indicators that measure environmental factors and social and demographic factors, all of which influence people's level of exposure, sensitivity, and adaptive capacity.

Gauging environmental factors

Measures of environmental factors represent key hazard pathways through which climate change affects human health:

- **Extreme heat** places people at risk for heat stress and related health outcomes, such as heat exhaustion and heat stroke. It can affect air quality, contributing to negative respiratory outcomes, particularly for people with preexisting conditions such as asthma.[152] Researchers measured vulnerability here by tracking how often local temperatures reach historical extremes.

- **Flooding** can cause death and injury, and it may also expose people to chemical and biological contaminants in floodwaters, leading to waterborne diseases and skin irritation.[153] It can also leave behind living, working, and schooling conditions with mold and mildew, which can affect the health of occupants.[154] The proportion of a state's population that resides within a Special Flood Hazard Area as designated by the Federal Emergency Management Agency (FEMA), a conservative measure,[155] determined vulnerability to floods. These areas have a 1 percent annual chance of coastal or riverine flooding.[156]

- **Drought** can reduce air quality, including by increasing the risk of wildfire and dust storms. The scarcity of water resources can affect livestock and crops, contributing to negative human health impacts through food insecurity.[157] Researchers measured drought vulnerability by the number of days with a drought event.

- **Wildfire** affects air quality through the release of particulate matter and other emissions that contribute to respiratory issues and even death.[158] In destroying property, wildfires can cause death and injury, and they can contribute to the contamination of the local environment, including water supplies.[159] Fires can also increase the risk of subsequent flooding due to the loss of vegetation. Researchers measured vulnerability to wildfire by the percentage of zones—defined by states—in a state that recently experienced a significant wildfire, defined as one that causes fatality, significant injury, and/or property damage.

- **Severe storms**, such as hurricanes and tornadoes, can cause serious injury and loss of life, destroy infrastructure (including healthcare facilities), and produce flooding that exposes people to chemical contamination and pathogens.[160] Lingering floodwaters can also contribute to mold and the proliferation of mosquitoes and the spread of vector-borne diseases. Researchers based vulnerability on the number of days in recent years with a severe storm—a storm with thunderstorm winds, a tornado, a tropical depression, or a hurricane—that caused injuries and/or deaths.

- **Disease vectors**, particularly mosquitoes and ticks, carry disease pathogens that can cause illness and death in humans. Researchers measured vulnerability to vector-borne diseases (for example, Lyme disease, Powassan virus disease, chikungunya, and West Nile virus) by the likely presence of three vectors: two mosquito genera (*Culex pipiens* and *Aedes aegypti*) and one tick genus (*Ixodes*). Lyme disease—the most common vector-borne disease in the United States—and Powassan virus each transmit through the bite of an infected tick, each producing minor symptoms such as fever or headache that can escalate to a more serious illness.[161] West Nile virus—the leading cause of mosquito-borne disease in the continental United States—and chikungunya virus spread through the bite of an infected mosquito (in rare cases, West Nile has also spread through exposure in laboratory settings, through blood transfusion and organ donation, or from mother to baby).[163,163] Fever and joint pain are common symptoms of diseases caused by both, with West Nile causing in rare instances encephalitis (inflammation of the brain) or meningitis (inflammation of the membranes that surround the brain and spinal cord).

These hazards are tied to geography and weather patterns, including extreme events. Researchers chose specific indicators based on the availability of reliable data for analysis at the state level. (See Table 4.) To be sure, a fuller understanding requires also tracking data at a smaller geographic scale, such as by county, census tract, or neighborhood.

Table 4

Measures of Vulnerability to Climate-Related Health Threats: Environmental Factors

INDICATOR	MEASURE	SOURCE
D1.1 Extreme heat	Number of days per year with a maximum temperature above the 95th percentile for the area, 2014–2016	CDC National Environmental Public Health Tracking Network
D1.2 Flooding	Percent of the population residing within FEMA-designated Special Flood Hazard Areas	CDC National Environmental Public Health Tracking Network
D1.3 Drought	Number of days with a drought event (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.4 Wildfire	Percent of zones with significant wildfire (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.5 Severe storms	Number of days with a severe storm causing injury or death (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.6 Disease vectors	Likely presence of each of three exemplar vectors, varied timeframes	NASA; CDC National Center for Emerging and Zoonotic Infectious Diseases, Division of Vector-Borne Diseases

Notes: Researchers aggregated state-level data on **extreme heat** from county-level data. FEMA defines Special Flood Hazard Areas as those that have a 1 percent annual chance of coastal or riverine **flooding**. The drought classification system of the Drought Monitor, a multiagency federal effort, defines a **drought** event. In the data, droughts begin when an area escalates to the "D2 (severe drought)" or "D3 (extreme drought)" classifications, or when droughts begin to significantly impact people, animals, or vegetation. Droughts end in the data when an area deescalates from these classifications, or when they cease causing significant impacts. Data on **wildfires** capture any significant forest fire, grassland fire, rangeland fire, or wildland-urban interface fire that consumes natural fuels and spreads in response to its environment. A "significant" wildfire is one that causes one or more fatalities, one or more significant injuries, and/or property damage. In general, the data do not capture forest fires smaller than 100 acres, grassland or rangeland fires smaller than 300 acres, and wildland-use fires not actively managed as wildfires. Data on **severe storms** include days with thunderstorm winds, a tornado, a tropical depression, a tropical storm, or a hurricane, as well as a related death and/or injury. Data on exemplar **disease vectors** capture three of particular concern: *Culex pipiens* and *Aedes aegypti* (mosquitoes), and *Ixodes scapularis* or *Ixodes pacificus* (blacklegged ticks). (See "Appendix A: Methodology" for details on data manipulation and scoring.)

Gauging social and demographic factors

In selecting measures for social and demographic factors, researchers first reviewed existing resilience and vulnerability indexes, including the CDC's Social Vulnerability Index (SVI).[164] Researchers largely based data collection on SVI's four domains: (1) socioeconomic status, (2) household composition and disability, (3) housing and transportation, and (4) minority status and language.[165] This assessment focuses on the following characteristics:

- **Poverty** restricts people's capacity to prepare for an emergency, to respond during an emergency, or to recover following a disaster.[166] For example, a lack of income or assets may prevent someone from investing in home improvements such as weatherization that could protect against storm damage. Poverty may cause some people to have trouble paying for utilities, leaving them without air conditioning or heat and vulnerable to extreme temperatures. It can also serve as a proxy for other aspects of vulnerability, such as underlying health conditions or access to healthcare.

- **Income inequality** represents the relative deprivation of those with low incomes. Areas with wide income dispersion tend to have relatively more residents who lack critical resources for resilience. Researchers measured inequality here using the Gini coefficient, a metric of income dispersion.

- **Age composition** indicates age-related vulnerability. Many climate-related health effects have a more pronounced effect on people who are elderly or very young. In some cases, these populations are more sensitive to exposure, such as extreme temperature. They are also likely to experience reduced mobility and to require caregiving and other supports. Researchers measured composition by calculating the percentage of the state population under age 5 or over age 64.

- **Race/ethnicity composition** reflects a number of social, economic, and health disparities. Many of these result from persistent patterns of marginalization, discrimination, and disenfranchisement. In the United States, race and ethnicity often influence where people live, which has a profound impact on their vulnerability to climate change. Discriminatory housing policies and practices that advantaged white people and restricted where people of color could live, such as redlining, continue to define exposure and sensitivity in cities across America.[167] The Edison-Eastlake neighborhood in Phoenix, Arizona, is one product of that segregationist history. Most of its residents are people of color; the majority reside in outdated, poorly insulated public housing. Trees shade a little more than 5 percent of Edison-Eastlake, and nighttime temperatures can be 10 degrees Fahrenheit hotter than in wealthier areas. The neighborhood's heat mortality rate is 20 times the county average.[168] Discrimination may also affect the resources for preparedness and recovery made available to areas and communities where minority groups live in disproportionate numbers.[169] This element of vulnerability is based on the share of a state's population that is nonwhite.

- **Disability** can make it harder for a person to navigate emergency response or recovery. Disabilities affect some people's mobility or cognition, meaning that planning must take their needs into consideration; they may need greater resources or support to cope with climate-related hazards and health effects. This assessment measures the percentage of a state's population with a disability.

- **Housing** provides crucial protection from climate-related hazards. The ability to shelter safely is a key component of resilience. This assessment focuses on the vulnerability of people who live in mobile homes, which are likely to suffer greater damage from storms and other natural disasters.

- **Transportation** represents a population's mobility, including its ability to evacuate in the event of an emergency. Private transportation also facilitates access to additional goods and services in the event of a local disruption. Researchers measured vulnerability based on motor-vehicle access, which, while being a significant contributor of greenhouse gas emissions, is the main mode of transportation in most of the country.

- **Language** affects people's ability to comprehend and act on public health messages and emergency alerts, such as evacuation instructions.[170] With limited or no English proficiency, a person or household may find it difficult to access the care or services they require. They may have trouble navigating complex systems to obtain health and social services, including long-term recovery benefits. They may also be subjected to discrimination in receiving those services. This is factored into the assessment by accounting for the percentage of households with members who speak limited English. Preparations must incorporate effective culturally and linguistically appropriate outreach, education, and services to meet the needs of such residents.

- **Education** is related to both income and poverty. A person with higher levels of educational attainment is likely to have greater access to information and may be more willing or able to act on that information effectively.[171] Someone who is more highly educated may find it easier to navigate the health and social services that support preparedness and recovery.[172] This is represented here by measuring the percentage of a state's adult population without a bachelor's degree.

"Nothing is inherent in one's race, ethnicity, income, or education level that precludes an appropriate response in an emergency. All people are made up of a constellation of characteristics that enable them to assist in some situations but require assistance in others. None should be viewed merely as a so-called victim group or a so-called rescue group."

Source: Centers for Disease Control and Prevention

Researchers drew relevant measures from the SVI or published literature, and they collected corresponding state-level data from the U.S. Census Bureau's American Community Survey. (See Table 5.) These variables should be understood as population characteristics that make certain groups more vulnerable than others; they do not determine an individual's vulnerability.[173] CDC researchers involved in the development of the SVI cautioned: "Nothing is inherent in one's race, ethnicity, income, or education level that precludes an appropriate response in an emergency. All people are made up of a constellation of characteristics that enable them to assist in some situations but require assistance in others. None should be viewed merely as a so-called victim group or a so-called rescue group."[174]

Table 5

Measures of Vulnerability to Climate-Related Health Threats: Social and Demographic Factors

INDICATOR	MEASURE
D1.7 Poverty	Percentage of people living in poverty, 2018
D1.8 Income inequality	Gini coefficient, 2018
D1.9 Age composition	Percentage of population under age 5 or over age 64, 2018
D1.10 Race/ethnicity composition	Percentage of population that was non-white, 2018
D1.11 Disability	Percentage of population with a disability, 2018
D1.12 Housing	Percentage of population living in mobile homes, 2018
D1.13 Transportation	Percentage of population without a motor vehicle, 2018
D1.14 Language proficiency	Percentage of households with member(s) who speak limited English, 2018
D1.15 Education level	Percentage of population age 25 or older without a bachelor's degree, 2018

Notes: The **Gini coefficient** summarizes dispersion of income, ranging from 0 (perfect equality) to 1 (perfect inequality). All social and demographic indicators relied on one-year estimates of the U.S. Census Bureau's 2018 American Community Survey (ACS). The ACS, like any other sample survey, is subject to error. Researchers based each indicator on the ACS's subject definitions.

To assess and compare states, researchers converted the disparate measures into a unified scoring system using, for each indicator, a state's value in relationship to the nationwide average. They then scaled scores by normalizing their distribution and truncating the results of outliers to reduce their influence, placing all scores on a spectrum of 0 to 10 for every indicator. (See Table 6.) Then, they averaged scores for individual indicators to calculate state scores for each subdomain—environmental factors and social and demographic factors—and the domain as a whole. (See "Appendix A: Methodology" for a detailed description of how scores were calculated.)

Table 6

State Scores Across Vulnerability Indicators

	ENVIRONMENTAL FACTORS						SOCIAL & DEMOGRAPHIC FACTORS								
	D1.1 Extreme Heat	D1.2 Flooding	D1.3 Drought	D1.4 Wildfire	D1.5 Severe Storms	D1.6 Disease Vectors	D1.7 Poverty	D1.8 Income Inequality	D1.9 Age Composition	D1.10 Race/ethnicity composition	D1.11 Disability	D1.12 Housing	D1.13 Trans-portation	D1.14 Language proficiency	D1.15 Education level
Alabama	5.5	5.2	6.3	3.4	7.0	6.2	6.9	6.3	5.4	5.4	7.0	6.9	4.8	3.9	6.7
Alaska	no data	4.5	2.9	3.4	1.8	0.0	4.0	2.1	2.1	5.8	4.7	4.5	6.2	4.4	5.3
Arizona	3.7	4.7	6.1	6.5	5.3	4.4	5.7	4.6	6.2	6.3	5.2	6.2	4.5	6.0	5.4
Arkansas	5.4	6.3	6.4	6.1	6.2	6.2	7.0	6.2	5.5	4.8	7.6	6.5	5.0	4.1	7.5
California	5.9	4.8	5.9	6.6	5.2	6.2	5.1	6.7	3.2	7.4	2.7	4.2	5.2	7.8	4.3
Colorado	1.8	3.5	6.2	6.4	4.5	2.4	3.2	4.2	2.9	5.2	3.0	4.4	3.5	5.3	2.9
Connecticut	5.9	5.2	5.9	3.4	5.0	4.4	3.7	7.3	4.8	5.3	3.1	2.7	6.1	6.7	3.2
Delaware	4.7	5.3	2.9	3.4	4.7	6.2	5.0	4.4	6.8	5.7	5.2	5.9	4.9	4.9	5.0
District of Columbia	5.6	0.9	2.9	3.4	4.0	6.2	6.7	8.5	1.9	7.4	3.9	1.9	8.6	5.8	1.3
Florida	6.5	8.4	6.2	6.5	6.4	4.4	5.5	6.5	8.5	6.3	5.4	5.8	4.7	7.2	5.2
Georgia	6.3	5.1	6.3	6.1	6.9	6.2	5.8	6.1	2.8	6.4	4.3	5.8	4.7	5.3	4.8
Hawaii	no data	6.6	6.6	6.6	4.0	4.4	2.6	3.3	7.1	8.2	3.9	2.1	6.1	6.9	4.4
Idaho	3.7	4.7	2.9	6.7	4.5	2.4	4.6	3.3	4.9	3.8	5.4	5.7	1.0	4.5	6.0
Illinois	4.3	3.8	5.8	3.4	5.6	6.2	4.7	6.3	4.2	5.8	3.4	3.6	6.8	6.2	4.1
Indiana	5.3	4.6	5.3	3.4	6.2	6.2	5.3	3.8	4.5	4.1	5.4	4.6	4.7	4.2	6.2
Iowa	3.0	7.1	6.1	5.7	6.2	4.4	4.2	3.0	5.8	3.3	4.0	4.2	4.3	4.6	5.6
Kansas	3.8	5.1	6.0	6.3	5.3	6.2	4.7	4.8	4.8	4.5	5.5	4.4	3.8	5.3	4.4
Kentucky	6.3	5.9	5.9	6.1	5.8	6.2	6.9	5.8	5.0	3.4	7.4	6.6	5.2	4.0	7.0
Louisiana	4.5	8.6	6.4	3.4	6.6	4.4	7.5	6.8	4.6	6.0	6.5	6.8	6.0	4.6	7.2
Maine	5.1	4.8	2.9	3.4	4.0	4.4	4.5	3.8	7.9	2.0	7.1	5.7	5.6	3.2	4.9
Maryland	5.1	3.7	2.9	3.4	5.7	6.2	2.7	4.1	4.0	6.6	3.7	3.1	6.1	5.7	3.0
Massachusetts	7.7	4.6	5.9	3.4	4.5	4.4	3.5	6.4	4.3	5.0	3.9	2.7	7.2	6.9	2.5
Michigan	5.5	3.3	2.9	3.4	5.5	4.4	5.8	5.1	5.4	4.6	5.8	4.8	5.7	4.4	5.4
Minnesota	4.8	2.9	5.6	5.7	5.2	4.4	3.2	4.0	4.6	4.1	3.3	4.0	5.2	4.9	3.7
Mississippi	5.3	7.0	6.0	3.4	6.5	6.2	7.9	6.1	4.5	6.1	7.0	7.3	4.7	3.0	7.6
Missouri	4.8	4.7	6.1	5.9	6.6	6.2	5.3	4.9	5.4	4.1	6.0	5.1	5.2	3.9	5.5
Montana	3.3	4.6	6.1	6.1	1.8	2.4	5.2	4.0	7.1	3.2	5.3	6.1	3.6	1.4	4.9
Nebraska	3.0	5.5	5.3	6.1	4.7	4.4	4.1	3.6	5.1	4.2	4.1	4.2	3.6	5.2	4.7
Nevada	4.4	3.7	2.9	6.5	1.8	6.2	5.2	5.2	4.4	6.7	4.7	4.7	5.6	6.8	6.9
New Hampshire	6.0	5.0	2.9	3.4	4.5	4.4	1.6	4.0	5.2	2.6	5.0	5.0	3.9	4.0	3.7
New Jersey	5.0	6.4	5.3	6.1	5.2	6.2	3.1	6.2	4.5	6.2	2.5	2.7	7.0	7.2	3.0
New Mexico	4.1	6.7	6.4	6.4	4.5	2.4	7.8	6.5	5.8	7.4	6.7	7.7	4.5	6.8	6.0
New York	6.2	4.8	5.3	3.4	5.7	4.4	5.5	7.9	4.7	6.2	3.7	3.5	8.4	7.5	3.6
North Carolina	5.2	4.8	5.7	6.0	6.1	6.2	5.7	5.8	4.6	5.6	5.2	6.7	4.3	4.9	4.8
North Dakota	4.1	5.2	2.9	3.4	5.0	4.4	3.9	3.1	4.7	3.5	3.2	5.2	3.7	3.9	5.4
Ohio	8.3	3.8	2.9	3.4	6.2	6.2	5.7	5.0	5.5	4.2	5.8	4.2	5.9	4.1	5.6
Oklahoma	2.6	5.2	6.4	6.6	6.0	6.2	6.4	5.2	4.7	5.4	7.0	5.9	4.2	4.7	6.7
Oregon	6.6	5.2	2.9	6.6	1.8	4.4	5.0	4.4	5.6	4.5	5.7	5.5	5.2	5.2	4.3
Pennsylvania	6.7	4.2	5.3	3.4	6.2	6.2	4.8	5.6	6.2	4.4	5.8	4.2	6.9	5.1	4.8
Rhode Island	7.7	5.2	5.3	3.4	1.8	4.4	5.2	5.2	4.9	4.9	5.8	2.8	6.6	6.7	4.2
South Carolina	5.9	6.4	5.7	6.1	6.2	6.2	6.3	5.7	5.9	5.6	5.9	7.5	4.7	3.9	5.8
South Dakota	3.1	5.4	6.2	5.7	5.2	4.4	5.3	3.2	5.9	3.8	4.3	5.7	3.0	4.0	5.6
Tennessee	5.7	4.0	6.0	5.7	6.1	6.2	6.3	5.8	4.8	4.7	6.5	5.9	4.3	4.1	6.1
Texas	3.5	6.3	6.8	6.4	7.1	4.4	6.1	6.1	2.5	7.1	3.7	5.3	3.8	7.5	5.2
Utah	3.1	1.5	6.2	6.5	4.0	6.2	2.7	1.6	2.1	4.2	1.7	4.0	1.7	4.9	4.1
Vermont	5.0	5.5	2.9	3.4	4.5	4.4	4.1	3.5	6.9	2.1	6.0	5.1	4.8	3.2	3.4
Virginia	4.4	5.3	5.3	3.4	5.8	6.2	3.9	5.6	4.0	5.7	4.2	4.7	4.7	5.2	3.3
Washington	7.1	3.9	2.9	6.5	1.8	4.4	3.7	4.3	4.1	5.2	4.7	5.1	5.2	5.9	3.7
West Virginia	6.2	7.1	5.3	3.4	4.5	6.2	7.3	5.5	7.8	2.2	8.1	7.3	6.1	1.8	8.3
Wisconsin	5.1	3.7	2.9	5.7	5.2	4.4	4.1	3.6	5.2	3.9	3.9	4.0	4.8	4.1	5.3
Wyoming	2.3	4.3	2.9	6.3	4.5	2.4	4.2	4.2	5.3	3.5	4.9	6.8	2.5	3.4	6.3

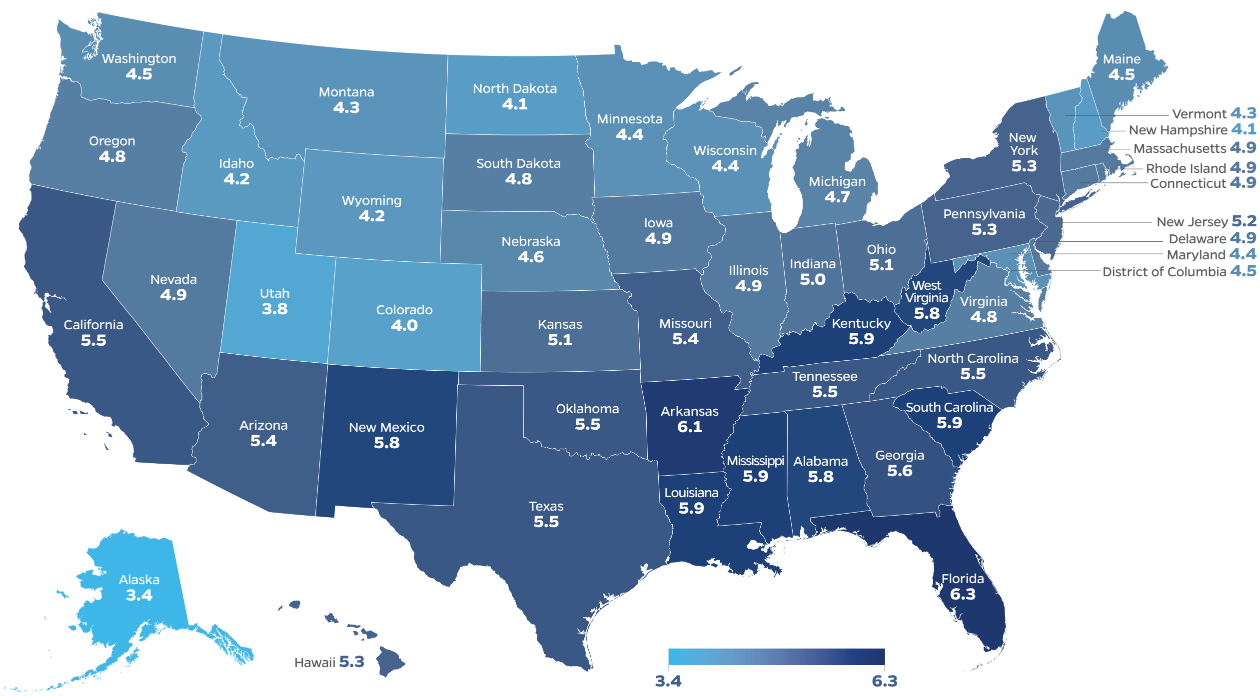
Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing greater vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Researchers displayed the scores on a green-yellow-red color scale, with reds reflecting relatively higher (more vulnerable) scores and greens reflecting relatively lower (less vulnerable) scores. Data on extreme heat (D1.1) were not available for Alaska or Hawaii.

Domain 1 findings

Vulnerability—accounting for environmental factors and social and demographic factors—vary across the country with clear regional patterns. (See Figure 4.) Southern and coastal states are the most vulnerable overall and within each subdomain, although this geographic pattern is more pronounced for environmental factors, as one would expect. The least vulnerable regions are the Northern Great Plains—states in the interior of the country tend to be less vulnerable—and the Northwest. Vulnerability is relatively low in the Midwest and the Northeast as well. In addition to being physically buffered from some climate-related hazards, these regions tend to be less racially and ethnically diverse than other parts of the country, and they generally have relatively low levels of income inequality.

The states found to be most vulnerable overall were Florida (6.3), Arkansas (6.1), Louisiana (5.9), South Carolina (5.9), Mississippi (5.9), and Kentucky (5.9). By contrast, the least vulnerable states were Alaska (3.4), Utah (3.8), Colorado (4.0), North Dakota (4.1), and New Hampshire (4.1).

Figure 4
Domain 1 State Scores



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Data on extreme heat (D1.1) were not available for Alaska or Hawaii; their scores do not capture that element of exposure.

Findings for environmental factors

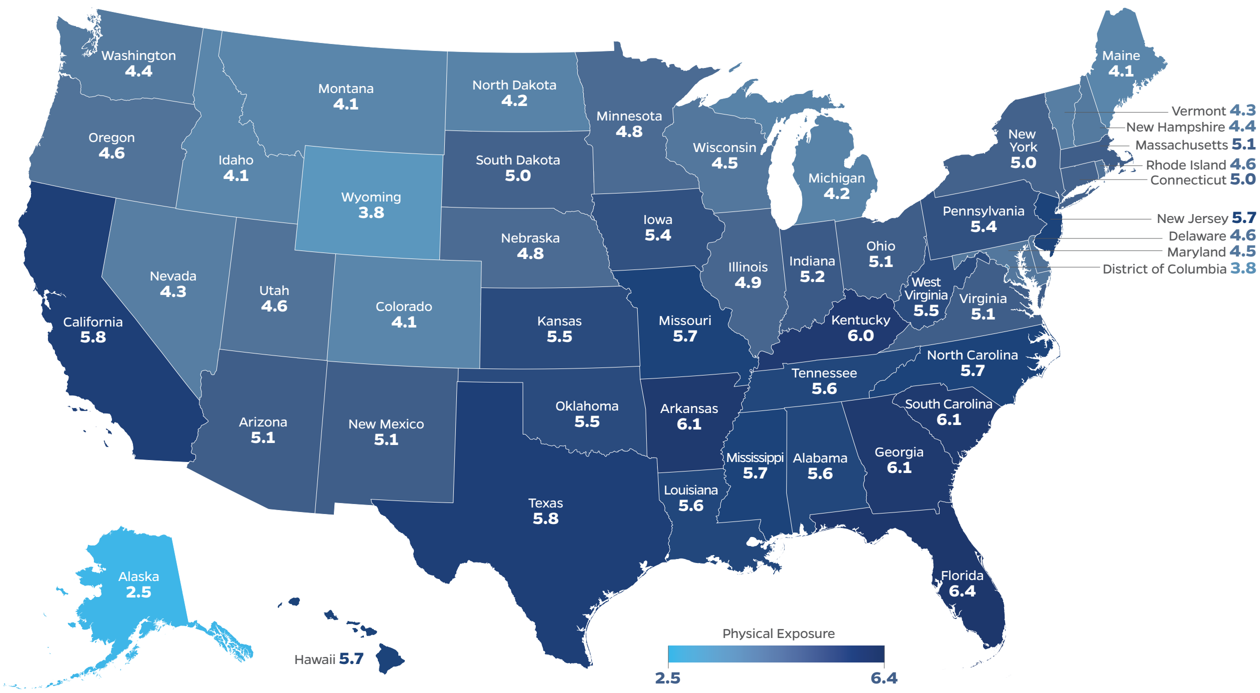
The states with the most dangerous levels of environmental vulnerability were Florida (6.4), Arkansas (6.1), Georgia (6.1), South Carolina (6.1), and Kentucky (6.0). Those with the least dangerous levels of environmental vulnerability were Alaska (2.5), Wyoming (3.8), the District of Columbia (3.8), Montana (4.1), Maine (4.1), Idaho (4.1), and Colorado (4.1).

For most measures of environmental vulnerability, distinct geographic patterns emerge (see Figure 5):

- Vulnerability to flooding tends to be highest in states along the Gulf Coast and the Mississippi River, along with Hawaii, the only island state. Less intuitively, a relatively large percentage of residents in New Mexico and West Virginia are also subject to flooding, owing in part to topography that creates the conditions for flash flooding near population centers.
- During the period from November 2016 through October 2019, drought was widespread across the country, with pockets of low vulnerability in the Northwest, the Northeast, and the Midwest around the Great Lakes.
- Wildfire vulnerability divides sharply: states are either at high or low risk. The western half of the country is the most vulnerable, and states in the Southeast also tend to be highly vulnerable.
- Severe storms, on the other hand, happened more frequently in the eastern half of the country, particularly in the Southeast, the Southern Great Plains, and parts of the Midwest.
- Most states fall within the range of at least one or two disease vectors. Only Alaska, with its colder climate, is outside the range of all three. Mountainous areas of the Southwest and the Northern Great Plains also appear less vulnerable to vector-borne diseases—with the exception of Nevada and Utah—due in part to their elevated altitudes.

Figure 5

Domain 1 State Scores, Environmental Factors



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater environmental vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Data on extreme heat (D1.1) were not available for Alaska or Hawaii; their scores do not capture that element of exposure.

Many, but not all, of these patterns are intuitive. A notable exception is the measure of extreme heat: interior states in the Southwest are less vulnerable to extreme heat than most other parts of the country. Many of these states are renowned for their scorching temperatures, so one might expect them to be more vulnerable to heat. However, the measure used for this analysis is a relative one, based on a state's own historical climate record. States accustomed to high temperatures may have a higher level of tolerance than relatively cooler states, reflecting both the acclimatization of residents (physiological adaptation) and interventions such as—absent power failures—cooling centers, air conditioning, and heat warning systems. Of course, while these tolerance factors provide some measure of added protection, temperatures exceeding high thresholds—often pegged at 95 degrees Fahrenheit—are dangerous anywhere, especially when combined with heavy humidity.[175] (*Note:* Data on extreme heat, D1.1, were not available for Alaska or Hawaii.)

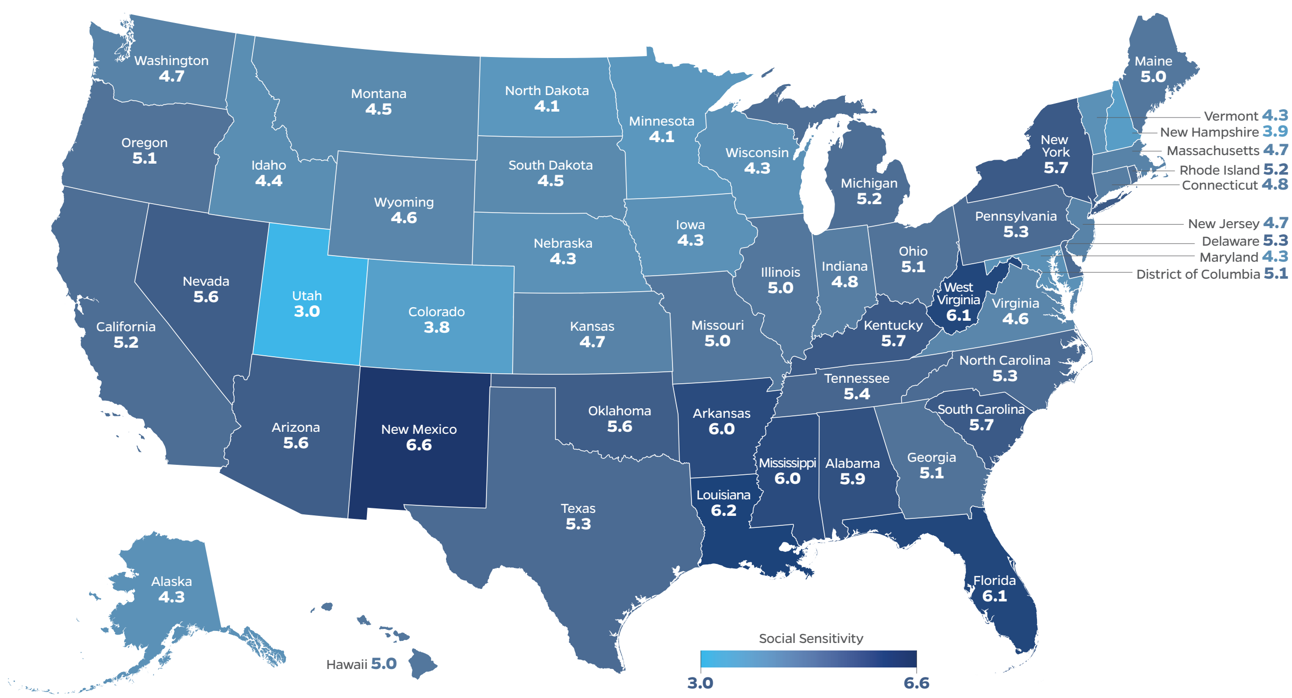
Findings for social and demographic factors

There are some notable geographic trends in social and demographic factors as well, particularly related to racial and ethnic diversity. (See Figure 6.) States in the Southeast and those bordering Mexico tend to have larger nonwhite populations than other parts of the country. New England states in the Northeast are the least diverse, followed by states in the Northern Great Plains. States near the southern border and those with large, populous cities (Illinois, Massachusetts, Nevada, New Jersey, New York) have the highest proportion of households that speak limited English. These states and their localities must consider how they will provide critical messages to such households and communities in a timely way.

States with the most serious levels of social and demographic vulnerability were New Mexico (6.6), Louisiana (6.2), Florida (6.1), West Virginia (6.1), Arkansas (6.0), and Mississippi (6.0). Those that were least vulnerable from a social and demographic standpoint were Utah (3.0), Colorado (3.8), New Hampshire (3.9), North Dakota (4.1), and Minnesota (4.1).

Figure 6

Domain 1 State Scores, Social and Demographic Factors



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater social and demographic vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5.

Poverty rates align closely with that of overall vulnerability: states with higher poverty rates tended to be more vulnerable across the board. This combination of fewer resources and greater environmental vulnerability presents real challenges for public health professionals and other state leaders as they try to prepare communities for the impacts of climate change. Limited financial resources and longstanding disinvestment make it difficult for individuals and communities to plan for, respond to, and recover from climate-related health emergencies and disasters. People who are poor may find it more challenging to evacuate in the event of a hurricane or wildfire; they are less able to invest in weatherization or fireproofing projects that could protect their residences and, at the same time, they will find it harder to rebuild if hurricanes or wildfires destroy their homes. States in the Southeast and the Southern Great Plains tend to have poorer populations, as well as a high percentage of people living in mobile homes. Given the regions' vulnerability to severe storms, these states must continue to invest in adaptation strategies that strengthen the population's capacity to shelter and recover from such disasters.

In many of these same states, a smaller percentage of the adult population has a bachelor's degree. Like poverty, lower levels of educational attainment affect adaptive capacity through access to resources and information, among other factors.[176] Those with postsecondary education may, more often than not, find it easier to access critical safety information and factor it into decision-making and actions. They may also generally have greater success navigating healthcare and social-service networks.[177]

Many of the poorest states also have a high proportion of people with a disability.[178,179] In addition to having physical or mental conditions that may make it difficult to navigate emergency response, those with disabilities may rely on adaptive technology, equipment, or medications to support their functional needs and/or survival. Elderly residents may face similar challenges. Reducing the vulnerability of these populations, therefore, requires careful planning and dedicated resources on the part of the state.

DOMAIN 2: PUBLIC HEALTH PREPAREDNESS

Public health preparedness: actions taken to build, apply, and sustain the capabilities necessary to prevent, protect against, and ameliorate negative effects from public health emergencies.

Source: Adapted from U.S. Global Change Research Program[180]

Extreme heat, powerful hurricanes, vector-borne diseases—the dangers climate change will pose over the next few decades are familiar ones. Rather than manifesting in new phenomena, climate change can be understood as a threat multiplier, particularly from a public health perspective. Combating its health impacts then does not require a wholly novel tool kit. As states begin to grapple with the effects of climate change, they can draw on their historical experience with natural hazards and other health threats.

Public health preparedness refers to a state of readiness to prevent, prepare for, respond to, and recover from incidents that pose public health risks. This explicitly includes new and evolving threats, such as those from emerging infectious diseases or previously rare natural disasters.[181] Public health preparedness comprises several key domains, including the following capabilities:*

- Detect and track disease and health patterns through surveillance and epidemiological investigation.
- Share accurate and actionable information.
- Effectively manage and coordinate different elements of an emergency response.
- Provide countermeasures that mitigate harm.
- Expand medical services as needed.[182]

Public health preparedness also includes the readiness and resilience of the community, achieved in part through the actions of public health and emergency management professionals. These capabilities transcend individual health threats and form the foundation of public health preparedness and response for all hazards, including those related to climate change.

Adaptation refers to interventions and investments that seek to limit the impact of specific risks related to climate change. With respect to public health, the goal is to reduce disease burdens, injuries, disabilities, suffering, and deaths.[183] In this way, adaptation can be understood as a form of prevention. Public health defines three levels of prevention: primary, secondary, and tertiary. At each stage, there is an opportunity for public health departments and their partners—including individuals and communities—to intervene and reduce harm through adaptation.[184] See, for example, how Vermont's Department of Health has organized related concepts around the three levels of prevention. (See Figure 7.)

* These represent a subset of capabilities that are necessary for all-hazard preparedness and response. The CDC's Center for Preparedness and Response (national standards for state, local, tribal, and territorial public health) and FEMA's National Preparedness System both outline additional capabilities.

Figure 7

Efforts by the Vermont Department of Health to Prevent Negative Health Effects

NEGATIVE HEALTH EFFECTS	PRIMARY PREVENTION *Anticipatory*	SECONDARY PREVENTION *Reactive*	TERTIARY PREVENTION *Inherently Reactive*
Extreme heat event-related health effects	Early warning protocols to communicate health alerts to the public Health Alert Network—used to communicate health alerts to healthcare providers and responders	Environmental Public Health Tracking Program—tracking of heart attacks	All-Hazards Emergency Preparedness Plan Emergency Operations Plan (Health Operations Center) Emergency Medical Services (EMS) System Vermont Emergency Response Volunteers (VERV) Epidemiology All-Hazards Plan
Extreme weather event-related health effects	Early warning protocols to communicate health alerts to the public Health Alert Network		All-Hazards Emergency Preparedness Plan Emergency Operations Plan (Health Operations Center) Emergency Medical Services (EMS) System Vermont Emergency Response Volunteers (VERV) Epidemiology All-Hazards Plan
UV radiation-related health effects	State Cancer Plan (sun protection education) Comprehensive Cancer Control	Vermont Cancer Registry	Comprehensive Cancer Control
Vector-borne and zoonotic infectious disease-related health effects	Vector-borne disease public education Central dead bird reporting line for West Nile Virus Sentinel non-human host surveillance: Deer Sera Survey for mosquito-borne Eastern Equine Encephalitis Virus Health Alert Network	Reportable Diseases surveillance Monthly Infectious Disease bulletin—provides brief and timely updates about issues of concern in infectious disease epidemiology National Electronic Disease Surveillance System	Early Aberration Reporting System (EARS)—reports automated syndrome-sorted data useful for examining trends to VDH every 24 hours from seven hospitals

NEGATIVE HEALTH EFFECTS	PRIMARY PREVENTION *Anticipatory*	SECONDARY PREVENTION *Reactive*	TERTIARY PREVENTION *Inherently Reactive*
Water quality and quantity variation- related health effects	Water test kits available for purchase for laboratory testing of private water Water testing and maintenance guidelines 800 line to Drinking Water Program offering technical advice on protective technologies for microbial or chemical treatments and on interpretation of water test results Blue-green algae reporting line and email Health Alert Network	Reportable Diseases surveillance	Early Aberration Reporting System (EARS) Town Health Officer complaint response and management
Aero-allergen and other allergen and irritant- related health effects	Health Alert Network	Vermont Asthma Program surveillance	Town Health Officer complaint response and management
Food production and quality disruption- related health effects	Food and Lodging Program sanitarian inspections Shellfish Sanitation Program Health Alert Network	Food and Lodging Program regulatory enforcement Reportable Diseases surveillance	Food and Lodging Program and Infectious Disease Epidemiology complaint, outbreak, and recall protocols Food and Lodging Sanitarian Emergency Response
Changing material and pesticide use-related health effects		Birth Defect Registry	

Source: Vermont Agency of Natural Resources; Department of Health[185]

While important strategies extend beyond the control or responsibility of public health agencies, traditional public health approaches and capabilities such as those described above remain critical. This means that having a strong public health preparedness program today is a vital determinant of successfully adapting to climate change tomorrow. Examining how well-prepared states are to address existing public health threats illuminates a great deal about how ready they are to respond to and adapt to climate change.

Measuring public health preparedness

To measure states' preparedness, researchers drew on the National Health Security Preparedness Index (NHSPI), a joint initiative of the Robert Wood Johnson Foundation, the University of Kentucky, and the University of Colorado.[186] The index provides an objective, annual assessment of America's progress in preparing for, preventing, and responding to large-scale public health threats, including natural disasters and disease outbreaks.[187] The 2019 NHSPI—the version posted at the time of research for this assessment—presents a progress report for each state, pulling data from over 60 sources to produce a comprehensive set of 129 measures.[188] The index organizes these measures into domains of health security.

Each domain comprises multiple subdomains related to specific aspects of policy and practice.[189] NHSPI uses a set of indicators to calculate scores for each subdomain, which are aggregated into summary scores for each domain and, ultimately, an index score for every state and the District of Columbia, as well as the country overall.[190] All scores are on a scale of 0 to 10, with 10 indicating the highest level of preparedness.

The NHSPI does not focus only on the actions, responsibilities, or effectiveness of public health departments or other state agencies. In alignment with existing national preparedness frameworks, NHSPI recognizes preparedness as a shared responsibility, requiring a whole-community approach (e.g., individuals and families, schools and academic institutions, faith-based and community organizations, businesses, nonprofits, media outlets, and all levels of government).[191,192,193] This reliance on stakeholders across government and society is especially apparent among certain indicator domains, but it is present across them all.

For this assessment, researchers selected a subset of 11 subdomains from the index based on their pertinence to the health impacts of climate change. (See Table 7.) Data amounting to scores for the subdomains were used to calculate an average score for each state across the subset, producing a score between 0 and 10 for each state. (See "Appendix A: Methodology" for a detailed description of how scores were calculated.)

Table 7
Climate-Related NHSPI Subdomains Measuring Public Health Preparedness

DOMAIN	SELECTED SUBDOMAIN(S)	DESCRIPTION
Health security surveillance	D2.1 Health surveillance and epidemiological investigation	The development and maintenance of systems and processes that enable detection, identification, and tracking of health threats, including disease outbreaks and adverse events.
Community planning and engagement coordination	D2.2 Cross-sector / community collaboration	The coordination necessary to engage community-based organizations and social networks through collaboration among state agencies and their partners in order to return to routine delivery of services effectively and efficiently.
	D2.3 Social capital and cohesion	The degree of connection and sense of belonging among residents, including social networks among individuals, neighbors, organizations, and governments.
Incident and information management	D2.4 Incident management	The ability to establish and maintain a unified and coordinated operational structure that appropriately integrates all stakeholders and supports the execution of core capabilities and incident objectives through information sharing, strategy development, and resource management.
	D2.5 Information management	The ability to develop systems and procedures that communicate timely, accurate, accessible, and appropriate information and alerts to the public using a whole-community approach.

DOMAIN	SELECTED SUBDOMAIN(S)	DESCRIPTION
Healthcare delivery	D2.6 Prehospital care	Care provided by emergency medical services (EMS), including 911 and dispatch, emergency medical response, field assessment and care, and transport to a hospital or between healthcare facilities.
	D2.7 Hospital and physician services	Care for patients who are formally admitted to a hospital or other institution for inpatient treatment.
	D2.8 Long-term care	A continuum of medical and social services, including skilled nursing and rehabilitation, designed to support the needs of people living in residential-care settings with chronic health problems that affect their ability to perform everyday activities.
	D2.9 Behavioral healthcare	The provision and facilitation of access to behavioral health services, including medical treatment, substance-abuse treatment, stress management, medication, and social-services networks.
	D2.10 Home care	Clinical and nonclinical care that allows a person with special needs to stay in their home, including skilled nursing visits, respiratory-care services, provision of durable medical equipment, hospice, and pharmacist services.
Environmental and occupational health	D2.11 Environmental monitoring	The systematic collection and measurement of environmental specimens (air, water, land/soil, and plants) to analyze the presence of an indicator, exposure, or response (warning and control). This includes monitoring the environment for disease vectors.

Note: Researchers adapted and lightly edited domain descriptions from NHSPI. See "Appendix B: Domain 2 Underlying Indicators" for a list of indicators tracked within each subdomain.

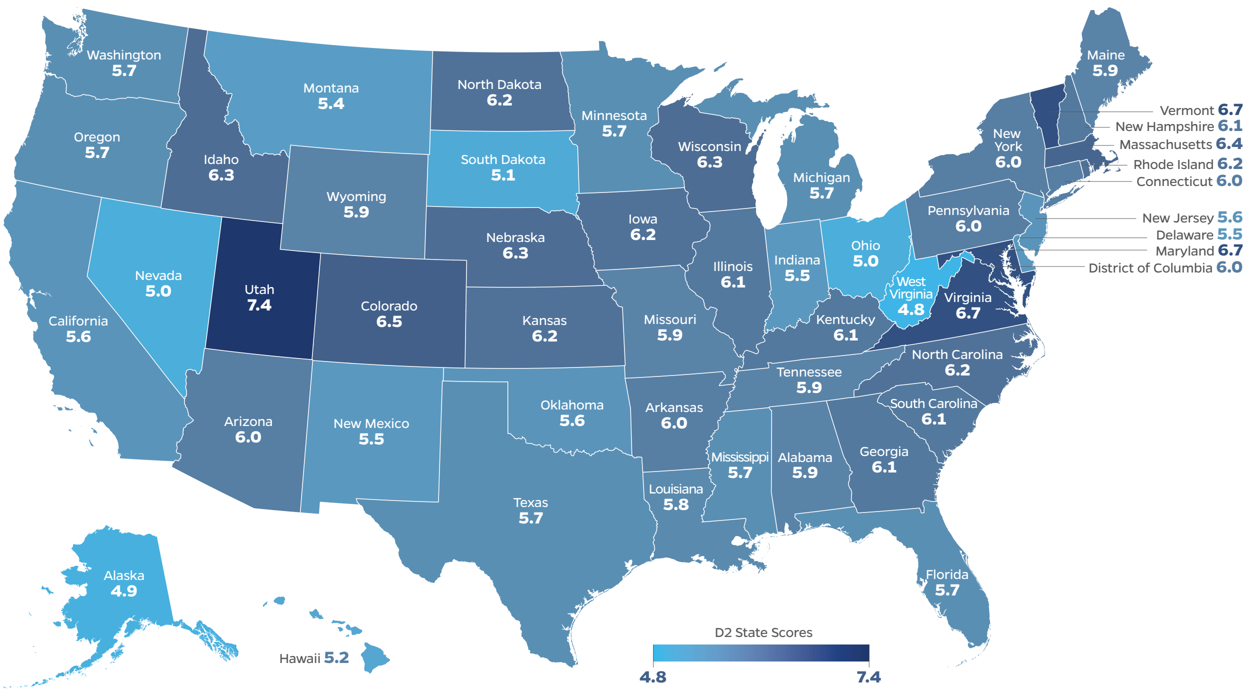
Source: National Health Security Preparedness Index[194]

Domain 2 findings

No state achieved the highest level of preparedness across all subdomains. States received an overall score of 5.9, on average, with a range of 4.8 to 7.4. Utah earned the highest score (7.4), followed by Maryland (6.7), Vermont (6.7), Virginia (6.7), and Colorado (6.5). Across the spectrum, West Virginia (4.8), Alaska (4.9), Nevada (5.0), Ohio (5.0), and South Dakota (5.1) earned the lowest scores. (See Figure 8.)

Figure 8

Domain 2 State Scores



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing greater preparedness. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5.

Within individual subdomains, state performances varied more widely. Typically, states performed best in the subdomains related to surveillance (D2.1), incident management (D2.4), and information management (D2.5), with the greatest room for improvement tending to be in the areas of social cohesion (D2.3), prehospital care (D2.6), and mental healthcare (D2.9). No clear patterns emerged—geographic or otherwise—with respect to the distribution of scores. (See Table 8.)

Table 8
State Scores Across Public Health Preparedness Subdomains

State	D2.1 Health surveillance and epidemiological investigation	D2.2 Cross-sector / community collaboration	D2.3 Social capital and cohesion	D2.4 Incident management	D2.5 Information management	D2.6 Prehospital care	D2.7 Hospital and physician services	D2.8 Long-term care	D2.9 Mental and behavioral healthcare	D2.10 Home care	D2.11 Environmental monitoring
Alabama	7	5.7	3.4	5.4	8.1	6.3	5.4	6.1	3.9	6.3	7.1
Alaska	8.2	5.2	5.8	4.8	5.6	2.9	3.6	7.1	4	2.9	4
Arizona	6.3	7.2	3.7	9.6	8.5	2	4.8	5.9	3.3	6.7	7.5
Arkansas	7.8	8.4	3.6	8.6	5.1	2.6	5.4	6.9	3.5	6.9	7.4
California	7	6.2	3.1	6.9	8.4	0.8	5.2	5.6	3.1	7	8.6
Colorado	6.4	7.4	4.9	9.4	6.2	6.3	5.8	7.1	4.1	7	7.3
Connecticut	4.9	8.8	4.3	6.6	8.5	4.2	6.4	5.4	4.3	7.1	5.2
Delaware	7.3	9	4.6	4.5	5.4	5.6	6.1	7.5	2	6.3	2.5
District of Columbia	7.2	10	5.3	6.4	5.6	7	6.7	5.7	3.7	5.3	3
Florida	7.8	6.7	3.2	9.5	5.7	3.2	5.4	5.9	3.3	6	6.4
Georgia	7.1	6.9	3.4	9.3	5.5	6.6	4.9	6.6	4.1	5.8	7.2
Hawaii	6.1	7.9	2.5	4.3	8.2	1.3	5.9	7.3	2.3	5.9	5.5
Idaho	6.7	7.4	5.1	9.2	8.6	4.4	4.9	6.1	4.8	7.7	4.6
Illinois	8.1	5.3	3.6	7	8.8	4.5	5.8	6	3.8	5.7	8.5
Indiana	8.7	3.2	4.4	3.9	8.4	2.9	5.8	5.4	4	5.7	7.8
Iowa	6.6	4.4	5.5	8.6	9	3.2	5.7	5.8	4.5	6.5	8.4
Kansas	6.4	6.8	4.5	8.6	8.5	7.1	5.8	5	3.1	7.2	5.4
Kentucky	8.5	5.5	3.7	9.3	8.2	3	5.4	6.6	3.8	6.3	6.4
Louisiana	6.5	7.5	3.3	7.3	5	2.1	5.3	7.3	4.9	6.8	8
Maine	6.1	7.8	5.9	6.9	8.7	4.7	6.2	4.6	2.7	7.1	4
Maryland	9.2	7.3	5.5	9.5	8.9	2.1	5.8	6.8	4.8	6.7	7.4
Massachusetts	9.5	8.4	4.6	6.5	9	2.8	6.1	6.5	3.2	6.8	7.2
Michigan	8.4	5.7	4	7.3	8.8	2.5	5.2	6	3.7	6	5.1
Minnesota	6	7.4	6.6	4.6	6.9	3.1	6.1	6	3.6	6.9	5.5
Mississippi	5.5	8.8	2.6	9.1	4.8	5	5.2	7.5	4.3	6.5	3.9
Missouri	8.6	5.7	4.3	8	5.8	4.8	5.8	5.7	2.6	7.1	6.1
Montana	8.2	8.6	5.3	7.1	5.6	4	4.9	4.1	3.5	5.4	3.2
Nebraska	9.7	8.4	5.5	8.8	6	5.9	5.4	5.9	4.1	7.2	2.5
Nevada	6.3	5.5	3.5	6	5.2	3	4.5	4.9	5.6	4.6	5.8
New Hampshire	7.2	3.5	5.6	5.6	9.7	6.4	6.3	5.6	3.9	7.7	6
New Jersey	6.1	6.2	3.7	6.3	5.8	2.6	5.9	6.8	5.1	5.3	7.4
New Mexico	8	5.6	3.2	8.9	4.9	3.2	4	4.3	3.7	7.1	7.2
New York	8.1	7.9	2.9	6.7	5.4	2.7	5.6	6.1	4	8.5	8
North Carolina	4.9	6.9	5	9.8	8.6	2.5	5.4	7	3	6.9	7.8
North Dakota	7.3	8.8	4.7	8.2	9	4	4.4	6.9	2.9	6.6	5.2
Ohio	3.7	5	4.6	6.4	6.1	2.6	6.2	6.1	3.7	6.6	4.5
Oklahoma	7.2	6.3	3.8	9.7	5.1	4.4	5.4	5.5	3	6.5	4.7
Oregon	8.5	7.3	6.9	4.2	6.4	4	5.6	3.6	3.5	5.8	7.3
Pennsylvania	6.8	5.3	4.9	7	8.6	4	6.1	5.5	3.6	7.2	6.8
Rhode Island	6.2	9.2	3.9	7.4	5.7	4.1	6.7	5.8	5.6	7.6	5.5
South Carolina	4.9	4.1	3.8	9.3	8.3	6.4	5.6	6.3	4.6	6.9	6.9
South Dakota	5.8	4	4.5	5.8	6.2	4.6	5.7	6.7	2.8	6.7	3.8
Tennessee	9.1	4.5	3.4	8.7	8.1	4.8	4.9	5.7	3.4	6.8	5.8
Texas	7.3	6.2	3.2	5.7	8.3	4.2	4.9	5.4	3.3	6.5	7.3
Utah	7.9	7.9	7.2	8.6	9	6.1	5.7	6.5	7.7	7.1	7.3
Vermont	10	9.1	5	5.4	8.6	3.7	6.7	7	4	7.2	6.5
Virginia	8.7	6.7	5.1	9	8.8	4.9	6.1	5.4	4.1	6.8	7.9
Washington	7.5	7.4	5.2	3.9	8.9	1.7	5.5	5.2	3.2	6.8	7.4
West Virginia	4.3	6.1	3	6.5	5.1	2.4	5.7	6.2	2.4	7.9	3.6
Wisconsin	7.4	7.5	5.7	7.9	6.5	3.4	6.5	5.9	3	7.5	8.4
Wyoming	9.6	6	4.3	6.9	5.6	7	5.4	6.5	5	5.8	2.7
State average	**7.2**	**6.8**	**4.4**	**7.3**	**7.2**	**4.0**	**5.6**	**6.0**	**3.8**	**6.6**	**6.1**

Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing greater preparedness. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Researchers displayed the scores on a green-yellow-red color scale, with greens reflecting higher scores and reds reflecting lower scores.

Source: National Health Security Preparedness Index[195]

Strong surveillance performance (D2.1), including syndromic surveillance, indicates the ability to identify and track health threats in time and space. Overall, states are rated highly in this area: 25 states scored higher than 7.2, the subdomain average, and six scored above 9.0, with Vermont receiving a perfect score. This capability is critical for detecting and containing the spread of diseases and other exposures that can hurt human health. Early detection allows jurisdictions to act when a threat is still minor, conserving resources and preventing illness, injury, or death. Surveillance also ensures that public health professionals know where the problem is occurring and who it is affecting, or most likely to be affecting. This again enables more effective deployment of resources. The data provided by surveillance and other elements of epidemiological investigation provide an essential body of evidence for jurisdictions seeking to understand the factors driving vulnerability in their communities. The high performance for this subdomain is therefore promising.

The health of people in a community cannot be separated from the health of the environment. As the global climate changes, changes in the local environment serve as critical harbingers of human health problems.

However, when it comes to climate change, the health of people in a community cannot be separated from the health of the environment. As the global climate changes, changes in the local environment serve as critical harbingers of human health problems, whether infectious-disease outbreaks or cardiovascular-disease events related to extreme heat. The ability to implement primary prevention through proactive adaptation interventions requires not only effective surveillance of human exposure and disease, but the early warning provided by detecting hazardous exposures in the environment. Yet, state performance on environmental monitoring (D2.11) was much lower overall than for health surveillance. Only six states scored at or above 8.0, with California topping the list at 8.6. Across all states, the average score was only 6.1.

States performed well on both incident (D2.4) and information management (D2.5)—critical to managing the acute phases of emergency response.[196] Compared with other measures, many states have strong capabilities in both areas: 12 states received a score of at least 9.0 on incident management, and five received a 9.0 or above on information management. Most states rated over 5.0 on both measures. As NHSPI researchers have noted, this strong performance is the result of a concerted national investment in “training government agencies, health professionals, and community leaders in the incident command process and in practicing these skills regularly through exercises, drills, and real events.”[197] As natural disasters become more frequent and intense, these capabilities will be even more essential to ensuring effective deployment of limited resources.

Still, the country's strength in managing acute emergency response is undercut by wide performance disparities in this domain and overall. As the climate changes, states can expect to deal with simultaneous, widespread, or long-lasting health emergencies. Their individual capabilities are likely to be overwhelmed more often, even as the federal government's capacity is stretched thin. States will need to rely more on one another, through mutual aid and assistance.[198] The ability to effectively deploy a standardized, scalable incident-management system will be critical to coordinating activities and resources across state lines.

Building capacity at the community level will also play an important role in the nation's ability to prepare for and respond to the simultaneous or prolonged health threats that climate change is bringing. Unfortunately, state performances on measures of community planning and coordinated engagement were relatively weak. While some responsibility for this set of measures clearly lies outside the control of public health departments and other state agencies, they still have an important role to play. The CDC includes both community preparedness and community recovery in its list of 15 core public health capabilities. Public health and emergency management professionals can support resilience by raising awareness, convening partners, promoting access to resources (especially those related to public health, healthcare, human services, behavioral health, and environmental health), and engaging in preparedness activities with communities.[199] Many of these functions are best achieved through partnerships—not only with community members and organizations, but also with federal, state, local, tribal, and territorial stakeholders. Effective engagement and coordination of interested parties at all levels and across sectors is critical.

In 2017, New York City launched Be A Buddy, a two-year pilot project aimed at increasing social cohesion and resilience to climate change by strengthening relationships between vulnerable communities and local organizations.[200] Under this community-led preparedness model, three local organizations received training, technical assistance, funding, and other resources to help the city disseminate public health messaging and implement check-ins to reduce vulnerability to health impacts from extreme heat and other weather-related emergencies.[201] In addition to providing training and engagement activities to bring together their staffs and community members, the organizations conducted screenings to identify people at higher risk for heat-related illness, and they recruited 64 volunteers to check on those residents as part of a "Be A Buddy network." From 2018 to 2019, the networks activated 17 times for extreme temperature events, reaching over 450 at-risk residents; in the project's first 19 months, they held 114 engagement events.[202]

On average, states' capacity to engage partners and foster collaboration across sectors (D2.2)—priorities often steered by localities, especially in large states—rated much higher than their level of social capital and community cohesion (D2.3). On cross-sector/community collaboration, 26 states scored above the average of 6.8, and four (Delaware, District of Columbia, Rhode Island, and Vermont) scored at or above 9.0, with the District receiving a perfect score. In contrast, the average score for social capital and cohesion was only 4.4. While half the states scored above this, 34 scored below 5.0. Social capital was generally weaker in the southern half of the country, stretching from California to Florida.

States' poorest performance, collectively, was on activities related to healthcare delivery. This domain examines the ability of healthcare providers and facilities to provide high-quality medical care during and after health emergencies.[203] It includes services related to the emergency itself, as well as those related to existing or unrelated patient needs. Each component addresses a specific aspect of the continuum of care: prehospital care (D2.6), hospital and physician services (D2.7), long-term care (D2.8), behavioral healthcare (D2.9), and home care (D2.10).

Performance varied across the subdomains, with states generally performing better in the areas of long-term care and home care than on other measures. Both represent relatively limited patient populations, and the underlying measures reflect this narrower scope. But they present unique challenges in that the populations they serve tend to be more vulnerable, complicating evacuation or raising the stakes around continuity of care.[204] When a nursing home in Florida lost power—and air conditioning—following Hurricane Irma in September 2017, 12 patients died. An investigation revealed that temperatures inside parts of the facility had soared to 99 degrees Fahrenheit, but the state has been slow to enforce its own new requirements for backup generators.[205,206,207]

In contrast, the other three subdomains address the needs of the general population. Prehospital and hospital services are likely to have a significant role in responding to an acute crisis. Strengthening these services will enable healthcare systems to maintain a high standard of care amid more frequent, intense, or protracted health emergencies.

Behavioral healthcare and prehospital care received the lowest average scores across all subdomains. Most states and the District of Columbia scored less than 5.0 on their ability to provide and facilitate behavioral healthcare services; 30 states and the District rated below 4.0. Utah was a clear standout for this subdomain, scoring (7.7), well above the next-highest group of states. Measures of prehospital care, or emergency medical services, rated somewhat higher. But 40 states still scored at or below 5.0, and the lowest score was 0.8 (California). Low performance in these two subdomains presents challenges for both acute response and recovery efforts, particularly for large-scale disasters such as hurricanes, floods, and wildfires. Mental health services, in particular, are a critical gap, as both immediate hazards and longer-term, more gradual losses posed by climate change are likely to have negative impacts on people's mental health. For instance, in its assessment of climate-related health threats, Alaska highlighted the risk of solastalgia—particularly for Indigenous communities—the distressing sense of loss that people experience from unwanted environmental changes (e.g., fires, floods, and storm surges; thawing permafrost and coastal erosion; weakening air or water quality, emerging disease vectors, and changing food sources) may also lead to adverse mental health outcomes near home.[208]

Individual state performance varied widely across the healthcare subdomains; a state might be the clear leader in one area and perform near the bottom in others. This may be due to the fragmented nature of the U.S. healthcare system, which comprises numerous independent health systems and providers across both the public and private sectors. Even within a single state, a variety of entities manage or fund different aspects of healthcare. While this presents a challenge, it also offers an opportunity for healthcare leaders to learn from one another and identify the best practices within their own state.

DOMAIN 3: CLIMATE-RELATED ADAPTATION

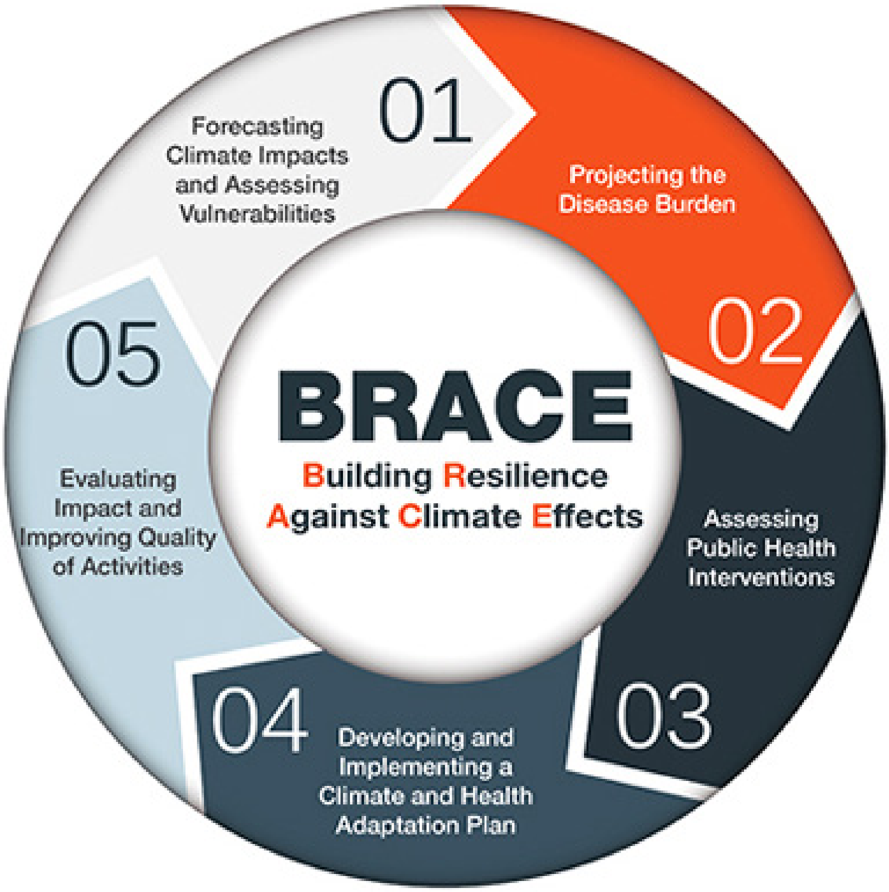
Adaptation: adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.

Source: U.S. Global Change Research Program[211]

Indicators within Domain 3 specifically measure how states are planning to adapt to the public health impacts of climate change. These preparations begin with identifying the nature and extent of current and future changes within a state's boundaries. Based on expected exposures, a state can determine the likely health outcomes, consider which residents are most vulnerable, and identify adaptive interventions most likely to protect people.

The Building Resilience Against Climate Effects (BRACE) framework, a five-step process developed by the CDC to guide states and other jurisdictions as they work to prepare for the health impacts of climate change on their communities, inspired the indicators and sub-indicators for this domain.[210] (See Figure 9.) Through its Climate-Ready States and Cities Initiative, the CDC provides financial and technical assistance to help health departments implement the framework. As of October 2020, the initiative supported 16 states, as well as health departments in New York City, San Francisco, and some tribes and territories.[211,212] But the framework is designed to have universal applicability—indeed, every state would benefit from incorporating its guidance into their preparations—so it provides a useful benchmark against which to assess progress.

Figure 9
The CDC's Building Resilience Against Climate Effects (BRACE) Framework



Source: Centers for Disease Control and Prevention[213]

Domain 3 contains two indicators that draw primarily on the first and third steps of the framework. The first indicator examines whether a state has assessed its vulnerability to climate change and related public health impacts; the second measures whether it has formally identified evidence-based adaptive interventions to address them. These two indicators broadly echo those in Domains 1 and 2, which look at each state's vulnerability, and each state's public health preparedness.

The two overarching indicators were broken down into a series of sub-indicators, discrete criteria that demonstrate a state's progress in understanding and preparing for projected health impacts. (See Table 9.) The sub-indicators represent the different types of information a state needs to develop effective plans for adaptation that protect people's health as the climate changes. These criteria pay particular attention to identifying people who are most at risk or least able to cope with changing exposures or health effects. Addressing the needs of these vulnerable populations is critical to preventing adverse health outcomes.

Table 9

Indicators and Sub-Indicators of State Progress on Climate Change Preparedness and Adaptation

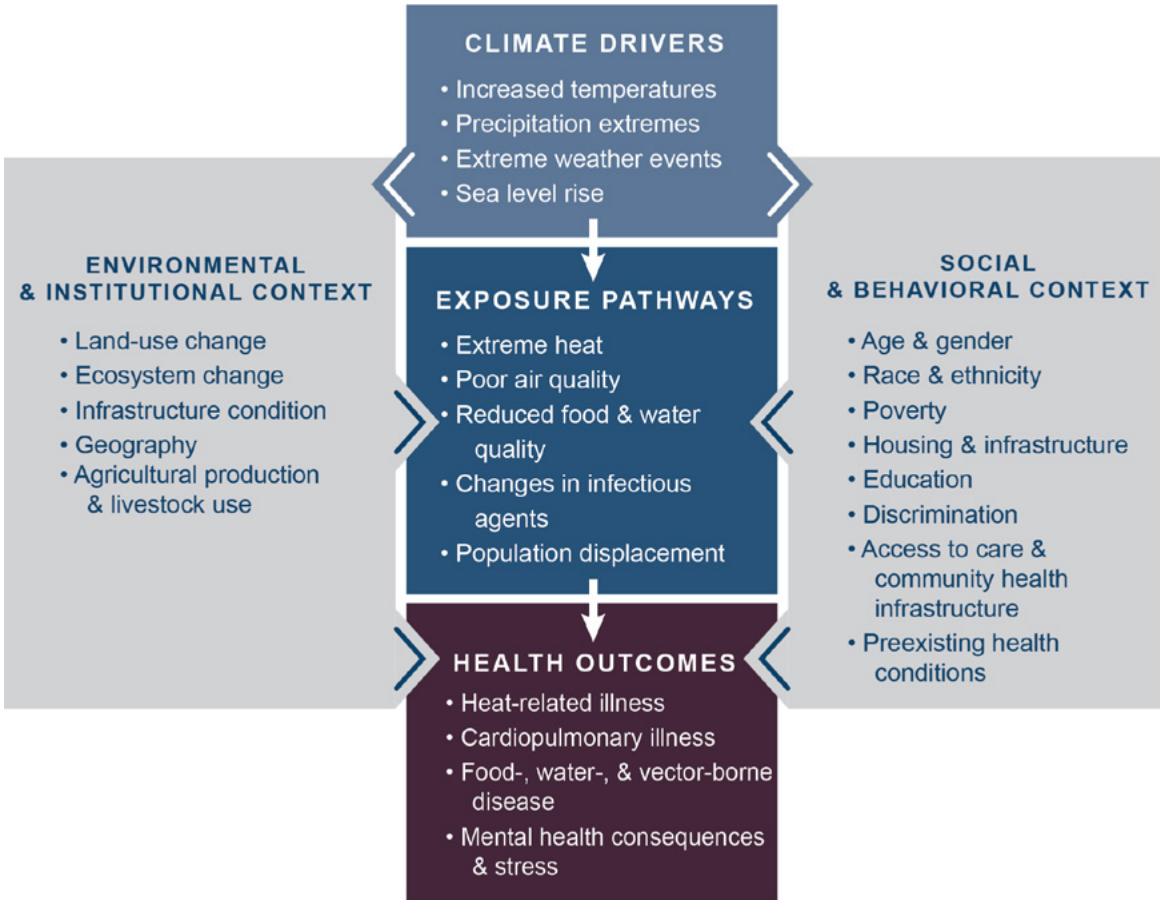
DOMAIN 3: CLIMATE-RELATED ADAPTATION	
Indicator D3.1	**D3.1 Sub-indicators**
Has the state assessed its vulnerability to the public health impacts of climate change?	D3.1.1: Have climate-related exposures (e.g., elevated temperatures, contaminated water, worsened air quality) to the state been identified?
	D3.1.2: Have climate-sensitive health outcomes (e.g., heat-related death and illness, gastrointestinal illness, premature death) been identified?
	D3.1.3: Have risk factors for health outcomes been identified?
	D3.1.4: Have causal pathways been developed for relevant climate-related hazards?
	D3.1.5: Have climate projections at the state, or state and local scale, been reported?
	D3.1.6: Have the most vulnerable populations in the state been identified (D3.1.6.1)? If so, have they been located (D3.1.6.2)?
Indicator D3.2	**D3.2 Sub-Indicators**
Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?	D3.2.1: Has the state identified interventions?
	D3.2.2: Are the interventions evidence-based?

The BRACE framework provides states and other jurisdictions with a set of guideposts—along with corresponding guidance—for developing, first, a detailed understanding of the specific threats they face and, then, a plan for addressing them. Using the framework, a jurisdiction begins by identifying its likely climate-related impacts. These impacts include changes in climate and weather, such as higher temperatures, heavy precipitation events, or prolonged drought, as well as indirect effects, such as rising sea levels, contaminated water, or poorer air quality. These types of climate-related impacts represent environmental exposures, factors that contribute to the health outcomes of individuals and populations. As part of the first step of BRACE, the state identifies specific health outcomes that climate-related exposures can cause and that the state finds to be most likely and acute: for example, vector- and water-borne diseases, heat-related illness, worsening asthma or allergies, or mortality related to wildfires or flooding.

Impacts vary by location, hence the need for assessing and addressing impacts locally, as BRACE recommends. To anticipate local impacts, a state must first identify the exposures it is likely to experience. States can do this qualitatively, but a more precise picture of local exposures requires the state to incorporate climate change projections. For many public health departments—and state agencies broadly—working with climate data and projections is a new experience; they may need to partner with federal or nongovernmental actors who can lend additional expertise. For example, the Florida BRACE program formed a collaborative that brought together staff with traditional epidemiological training with partners who possessed expertise in disciplines such as health education, environmental science, urban planning, demography, sustainability, geography, climatology, and meteorology.[214] The CDC has compiled guidance to help jurisdictions complete BRACE steps, including information on how to obtain and use climate data for projections, which typically address a range of greenhouse gas emissions scenarios.[215,216] Based on the temperature increase predicted under each scenario, the state may experience a different type or scale of climate-related exposures. These exposures, in turn, contribute to the scope of public health impacts a state is likely to experience.

In Step 2 of the framework, a state uses the climate and health profile created in Step 1 to take a closer look at how climate change will affect the burden of disease and ill health (i.e., the marginal difference in death and loss of health caused by climate change) within its borders.[217] For the purposes of this assessment, researchers did not examine whether states have begun developing climate change health-impact projections. Instead, the focus is on whether and how states are taking preparatory steps related to the relationship between climate change and health outcomes among their populations. Moving from climate-related exposures to public health impacts requires states to examine relevant causal pathways. (See Figure 10.) To do so, two primary questions must be answered: (1) how does climate change affect the environment a person is exposed to, and (2) how does a particular exposure act on a person's health?

Figure 10
Mapping Pathways from Climate to Health



Source: U.S. Global Change Research Program[218]

Some pathways are straightforward. (See Figure 11.) For example, scientists expect rising surface temperatures to produce an increase in the number of days with extreme heat, which could lead to an increase in heat-related illness and death. But other pathways are less direct and more complicated. In many communities in the United States, climate change is expected to increase the frequency and intensity of heavy precipitation events. These events can produce flooding, particularly in areas near bodies of water or with a large number of impermeable surfaces. Flooding events can directly produce injury and loss of life. The impacts do not stop there, though. If floodwaters infiltrate a home or other building, they can create conditions for mold growth, leading to respiratory issues and other negative health outcomes. Flooding can cause sewers to overflow or wash other pollutants into streams, rivers, and lakes that people use for recreation or drinking water, contributing to gastrointestinal illness or skin irritation. Certain kinds of contamination may lead to the growth of harmful algal blooms, which have their own serious health repercussions.

Figure 11
Examples of Climate-Related Health Impacts

	Climate Driver	Exposure	Health Outcome	Impact
Extreme Heat	More frequent, severe, prolonged heat events	Elevated temperatures	Heat-related death and illness	Rising temperatures will lead to an increase in heat-related deaths and illnesses.
Outdoor Air Quality	Increasing temperatures and changing precipitation patterns	Worsened air quality (ozone, particulate matter, and higher pollen counts)	Premature death, acute and chronic cardiovascular and respiratory illnesses	Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death.
Flooding	Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events	Contaminated water, debris, and disruptions to essential infrastructure	Drowning, injuries, mental health consequences, gastrointestinal and other illness	Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.
Vector-Borne Infection (Lyme Disease)	Changes in temperature extremes and seasonal weather patterns	Earlier and geographically expanded tick activity	Lyme disease	Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.
Water-Related Infection (*Vibrio vulnificus*)	Rising sea surface temperature, changes in precipitation and runoff affecting coastal salinity	Recreational water or shellfish contaminated with *Vibrio vulnificus*	*Vibrio vulnificus* induced diarrhea & intestinal illness, wound and blood-stream infections, death	Increases in water temperatures will alter timing and location of *Vibrio vulnificus* growth, increasing exposure and risk of water-borne illness.
Food-Related Infection (*Salmonella*)	Increases in temperature, humidity, and season length	Increased growth of pathogens, seasonal shifts in incidence of *Salmonella* exposure	*Salmonella* infection, gastrointestinal outbreaks	Rising temperatures increase *Salmonella* prevalence in food; longer seasons and warming winters increase risk of exposure and infection.
Mental Health and Well-Being	Climate change impacts, especially extreme weather	Level of exposure to traumatic events, like disasters	Distress, grief, behavioral health disorders, social impacts, resilience	Changes in exposure to climate- or weather-related disasters cause or exacerbate stress and mental health consequences, with greater risk for certain populations.

Source: U.S. Global Change Research Program[219]

In some cases, there may be uncertainty about how changing exposures will affect health outcomes. This is particularly true with complex systems like vector-borne diseases. The more carefully a state considers potential pathways, the more it can prepare for—and protect against—the likely health impacts.

It is critical that states and their localities know who and where vulnerable populations are so they can direct interventions effectively.

Understanding exposure pathways also enables a jurisdiction to identify who is most at risk or vulnerable. Risk factors are characteristics that make an individual more likely to experience a specific health outcome. They are an important element of vulnerability, but they do not tell the full story. As described in the section on Domain 1, vulnerability encompasses a person's sensitivity and susceptibility to the exposure as well as their ability to cope with the exposure and its impacts. Some populations are vulnerable based on their location. They may be more likely to experience an exposure (e.g., if they live in a county with frequent flooding events) or they may be at higher risk for negative health outcomes related to an exposure (e.g., if they live close to a dam or levee in that county). Vulnerability can also be tied to demographic factors, such as income, race (because of structural and systemic racism), or age. These factors may influence the risk of exposure, the likelihood or severity of illness, or the availability of coping tools. It is critical that states and their localities know who and where vulnerable populations are so they can direct interventions effectively.

Once a state has assessed its vulnerabilities, it is ready to start identifying the best strategies to protect its population from these threats. Adaptation is the primary strategy for public health and the focus of this report. In Step 3 of the BRACE framework, states contemplate the types of interventions they will implement. While practical considerations such as budget constraints inevitably influence decision-making, identified interventions should reflect the scale of the threat, be evidence-based, and be appropriate for the needs of the population overall and especially its most vulnerable groups.[220]

The framework provides a tool for public health departments and their partners to think iteratively about the threats posed by climate change and the actions they can take to protect people's health. Essential to the BRACE approach is an emphasis on following the best available science.[221] Throughout the process, decision-makers rely on data and evidence to determine which impacts are likely, to identify the most promising adaptive interventions, and to evaluate whether these interventions are working as expected. BRACE encourages states to learn and adjust their approaches based on new information, which will be critical to successfully adapting as the threat of climate change evolves.

Under the CDC's Climate-Ready States and Cities Initiative, the BRACE steps are sequential.[222] This sequence is logical and preferred, but it is not necessary. In practice, jurisdictions may implement certain steps simultaneously or out of order. Even among grantees, there has been variation in how states implement the framework. For grantees and non-grantees alike, it may make sense to begin with a step that can build on existing work, including work done by other state agencies, other states, or the federal government.

For this reason, while based on elements of the BRACE framework, the sub-indicators used for this assessment are, for the most part, not contingent on one another. There are two exceptions: (1) to locate vulnerable populations (D3.1.6.2), states must first identify them (D3.1.6.1); and (2) similarly, states did not receive credit for evidence-based interventions (D3.2.2) if they did not identify any interventions to protect their populations from the health effects of climate change (D3.2.1). For all other sub-indicators, researchers measured states' preparations independently.

Collecting data for the assessment

To answer the questions posed by the indicators and sub-indicators, researchers collected and reviewed state-level documents related to climate change and health. Researchers defined relevance broadly and applied an inclusive strategy to gathering documents to account for varied approaches by governments. Documents had to be produced by the state government or at its direction (e.g., assessments from an academic institution commissioned by a state agency), but otherwise, researchers could include any document that addressed climate change or its effects on human health in the assessment. Data did not have to come from reports modeled on the BRACE framework, or even focus solely on climate change and its public health implications. While the framework is specifically geared toward public health agencies, documents for this assessment could come from any agency or government entity.

Because each state must develop a hazard-mitigation plan to be eligible for certain kinds of non-emergency disaster assistance from FEMA, these documents became the starting point for assessments.[223] States must develop and adopt a new or updated hazard-mitigation plan every five years, following guidelines set out by the agency.[224] FEMA reviews and approves the plan and can provide technical assistance, but the states themselves lead the process of evaluating and mitigating hazards.[225] In many ways, FEMA's hazard-mitigation planning process aligns closely with the BRACE framework, albeit with a broader view of potential threats and impacts. Through it, states assess their vulnerabilities and identify interventions to reduce the risks posed by top-priority hazards.[226]

Hazard-mitigation planning requirements derive from federal law, and FEMA provides guidance to ensure consistent application of the legal requirements by states and federal evaluators.[227] FEMA incorporates principles from presidential directives and other relevant federal policy, such as the National Mitigation Framework. According to the version of the guide that went into effect in March 2016, states must consider the probability of future hazard events as part of the risk assessment in their plans,

and FEMA explicitly identifies changing environmental or climate conditions as a key element of risk they must address.[228] Thus, state hazard-mitigation plans are a useful baseline for understanding how each state is preparing for the impacts of climate change. These plans do not necessarily address public health impacts, however.

Whenever available—indeed, for most states—data were pulled from additional state documents to address each sub-indicator. To identify relevant documents, data collectors first looked to four existing repositories of state-level adaptation resources:

1) Georgetown Climate Center's Adaptation Clearinghouse[229]
2) Center for Climate and Energy Solutions' (C2ES) U.S. State Climate Action Plans database[230]
3) EcoAdapt's 2019 report *The State of Climate Adaptation in Public Health: An Assessment of 16 U.S. States*[231]
4) CDC's Climate-Ready States and Cities Initiative grantee website.[232]

Researchers identified additional documents using an advanced Google search of state government websites, employing the following terms: "[state name] climate change adaptation." For all documents, researchers assessed relevance by skimming tables of content and using a keyword search with the terms: "climate change," "climate," and "health." Within relevant documents, researchers looked for data that addressed each indicator and sub-indicator within the third domain of the assessment, and they collected excerpts of relevant data to illustrate a state's preparations.

Once researchers completed an analysis of documents for every state, they sent state leaders—typically, the highest-ranking public health and emergency management officials—a copy of the data collected for their state and requested that they or their designees verify the data's accuracy and completeness. Researchers invited states to share additional documents or excerpts that contained information relevant to the assessment: 29 states responded.* Researchers reviewed and reconciled the information provided in state responses to correct data gaps or errors.

* States that responded included Alabama, Arkansas, Arizona, Connecticut, Delaware, Georgia, Iowa, Idaho, Indiana, Kansas, Massachusetts, Maryland, Michigan, Minnesota, Missouri, Montana, New Hampshire, Nevada, New York, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Utah, Virginia, Vermont, and Washington.

Analyzing state data

After data were collected and offered to state officials for verification, researchers used them to score sub-indicators dichotomously, based on the presence or absence of relevant data in the state-produced materials. For example, if a state documented at least some relevant health outcomes that it expects to change or worsen, it received credit for the corresponding sub-indicator (D3.1.2). To limit subjectivity and preserve consistency in this assessment, researchers did not evaluate the content or extent of the data presented. That is, they did not factor into the assessment the veracity, completeness, or depth of the data provided. This approach obscures in some cases meaningful differences between states that had taken tentative early steps and those that had made more substantive progress.

To compare states, researchers scaled scores by normalizing their distribution and truncating the results of outliers to reduce their influence, placing all scores on a spectrum of 0 to 10 for every indicator. Then, they averaged scores for individual indicators to calculate state scores for the domain as a whole. (See "Appendix A: Methodology" for a detailed description of how scores were calculated.)

For sub-indicators D3.1.1 and D3.1.2, states had to identify at least one climate-related exposure and climate-sensitive health outcome, respectively. For the latter, this assessment required states to be specific; it was not sufficient to simply mention that climate change could cause poor health or loss of life. Ideally, risk factors and vulnerable populations would correspond directly to the identified exposures and health outcomes. However, for the purposes of this assessment, researchers permitted the identification of any reasonable risk factors or vulnerable populations, though risk factors had to be tied explicitly to health outcomes.

Domain 3: Climate-Related Adaptation

Indicator D3.1: Has the state assessed its vulnerability to the public health impacts of climate change?

- **D3.1.1:** Have climate-related exposures been identified?
- **D3.1.2:** Have climate-sensitive health outcomes been identified?
- **D3.1.3:** Have risk factors for health outcomes been identified?
- **D3.1.4:** Have causal pathways been developed?
- **D3.1.5:** Have climate projections been reported?
- **D3.1.6:** Have the most vulnerable populations been identified (D3.1.6.1)? If so, have they been located (D3.1.6.2)?

Indicator D3.2: Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?

- **D3.2.1:** Has the state identified interventions?
- **D3.2.2:** Are the interventions evidence-based?

Researchers allowed for a wider approach to vulnerability identification and mapping than that prescribed by the BRACE framework. A state could receive credit for identifying vulnerable people based on environmental factors or social or demographic factors, such as age, income, race or ethnicity, or occupation. Researchers did not require states to assess social or demographic factors strictly through the lens of climate change and its public health impacts. Location had to be precisely defined—for example, at the census tract or county level—except in cases where states broadly addressed urban/rural disparities, such as those that might be expected with vulnerability to extreme heat. This assessment employed this more permissive approach to acknowledge that broader vulnerability assessments, particularly those related to natural disasters or other environmental hazards, can play an important role in guiding climate and health planning. For example, FEMA requires that states conduct a vulnerability assessment as part of the hazard-mitigation planning process, and many contain useful information for climate-related preparations.[233] However, those focused only on geography and economic losses based on historical data are less applicable, and states should be mindful of the distinctions.

For indicator D3.2, researchers included any intervention that was reasonably specific and relevant to climate-related health impacts. Clearly, however, not all interventions were rigorously identified or selected. The second part of this indicator examined whether interventions were evidence-based. Recognizing that the published scientific literature on adaptive interventions remained limited, researchers applied a generous definition to "evidence-based."[234] States could meet the threshold by citing evidence that the intervention had been implemented and that it was effective within the state or in another state, or by citing credible evidence that the intervention would be effective for the identified risk. Failing to meet any of these criteria, researchers would still consider an intervention evidence-based if a relevant CDC BRACE guidance document classified it as "scientifically supported," grounded in "some evidence," or supported by "expert opinion."[235]

Researchers did not assess states on the degree to which they had successfully implemented interventions, or on the interventions' effectiveness in meeting intended objectives. Certainly, these are critical determinants of whether residents are ultimately protected adequately and equitably, but they were outside the scope of this project.

PREPARING FOR CLIMATE-RELATED HEALTH IMPACTS IN MICHIGAN

Michigan has been actively involved in climate and health efforts since 2009, when it received an 11-month planning grant from the Association of State and Territorial Health Officials (ASTHO)—sub-awarded from a CDC grant to ASTHO—to conduct a needs assessment and to prepare a strategic plan to address the health impacts of climate change.[236,237]

Through the needs assessment, the state used the 10 Essential Public Health Services to examine current work and gaps related to the health effects of climate change.[238,239] Among other findings, the state determined that, while all local health departments had comprehensive all-hazard emergency plans (including for some types of extreme weather), none specifically addressed climate change. In a survey of local public health practitioners, only 9 percent indicated that their department provided public information or education on the health effects of climate change.[240] Information from the needs assessment informed the development of a five-year strategic plan. The strategic-planning process, led by the state health department and an outside facilitator, brought together stakeholders from other state agencies, local health departments, major research universities, and nonprofit and professional advocacy organizations. The importance of identifying and involving partners early was one of the planning team's main lessons. The involvement of universities fostered particularly rich partnerships, "start[ing] a dialogue on Michigan-specific research needs" and identifying resources to support that work, as well as the planning itself.[241] The health department recommended that other states looking to undertake similar work engage not only local health departments but also local government or community planners, especially those focused on sustainability, walkability, and green planning.[242]

The team also highlighted the time and staffing commitment involved, noting the complexity of the subject and the lack of easily digestible or locally relevant information to guide their work.[243,244] Climate change had not previously been a focus of the state health department; the planning grant "provided critical resources and a structured process to begin raising awareness of the issue in Michigan and to engage the public health community as well as the environmental and emergency planning communities in development of a statewide coordinated plan."[245] This work led to the launch in 2010 of the Michigan Climate and Health Adaptation Program (MICHAP).[246]

That same year, Michigan joined the CDC's Climate-Ready States and Cities Initiative as part of its initial cohort. The state health department received a three-year grant (2010–2013) to support the implementation of its strategic plan. While there were some challenges in reconciling the original plan and the CDC's implementation expectations, the new funding allowed the department to undertake a more ambitious implementation program.[247] Many early efforts focused on educating state and local health department staff, as well as the public. MICHAP also invested in establishing and strengthening partnerships to facilitate the integration of state and local climate-related activities—for example, the program has worked with the Land Information Access Association to provide training and to incorporate public health into other climate-resiliency planning, and it has worked with the Detroit Climate Action Collaborative to address environmental-justice issues.[248,249] The program also expanded environmental health surveillance to track the health impacts of severe weather; similarly, the program expanded environmental health preparedness plans to include natural disasters.[250]

The growing number of extreme heat events and the resultant heat-related illness and mortality have topped MICHAP's list of priorities since the program's establishment. In addition to improving surveillance of heat-related illness and mortality, the health department helped pilot two heat-related decision tools in its first three years:[251]

1) The Internet-Based Heat Evaluation and Assessment Tool, or I-HEAT, developed by the University of Michigan to map heat-related vulnerability and land surface temperature.[252,253]

2) A dynamic heat model, developed by Michigan State University, that incorporates heat-related social and behavioral factors in order to help decision-makers evaluate intervention options.[254,255]

During this same period, MICHAP supported two local health departments in conducting over 3,000 surveys to assess residents' heat vulnerability and readiness.[256] A heat wave in summer 2012 provided an opportunity to show what the program had accomplished in its first two years. For example, syndromic surveillance was used to track the impact of extreme heat on emergency department visits and to develop appropriate public health messaging. Afterward, the state health department hosted local officials to discuss their responses to the event.[257]

A second three-year grant (2013–2016) introduced the CDC's BRACE framework into MICHAP's work.[258] During this phase, MICHAP collaborated with partners to produce the Michigan Climate and Health Profile Report and conducted a statewide vulnerability assessment.[259,260] It also worked with Great Lakes Integrated Sciences + Assessments, a partnership between the University of Michigan and Michigan State University, to develop downscaled climate models for the state.[261]

Since its inception, MICHAP has worked with partners across the state to encourage and support community planning pertaining to climate-related health impacts, particularly by building local capacity to conduct health-impact assessments.[262,263,264] Under its updated strategic plan (2016–2021) and third round of CDC funding, MICHAP has intensified its focus on implementing and monitoring adaptation strategies that address priority climate-related health outcomes, particularly for the most vulnerable communities.[265] Pilot interventions in Detroit and Marquette County—representing urban and rural parts of the state, respectively—will help to inform broader efforts and tools for local planning.[266,267,268]

Despite significant investments and progress, challenges remain. Michigan does not have an overarching climate change adaptation plan, although the state's 2009 Climate Action Plan recommended developing one.[269] Health is one of the only sectors to have its own action plan.

May 2020 dam failures in Midland County served as a harsh reminder of the risks posed by climate change, as well as the challenges for health departments and other state officials in preparing for them.[270] State authorities, already grappling with the COVID-19 pandemic, were suddenly faced with another emergency. Floodwaters ran through a Dow Chemical Company complex and an adjacent Superfund site.[271] With more frequent extreme rainfall events projected under climate change, on top of the nation's aging infrastructure, the event presaged additional disasters.[272,273]

Dam failures pose real threats to human health, both immediately and in the longer term. Yet most of the relevant hazard mitigation and adaptation activities fall outside the scope of public health departments. Addressing the health risks and vulnerabilities of climate change depends on multiple sectors and many different partners. Effective preparedness and adaptation will require investments and cooperation across sectors, as well as strategic direction from state leaders and their regional and federal partners.[274]

Domain 3 findings

Encouragingly, every state has documented at least some preparation for the impacts of climate change. By and large, states have begun to analyze the climate-related exposures they are likely to face and the impacts each could have, including on public health. This foundation may be attributed in part to FEMA's hazard-mitigation planning requirements, described above. Many states, however, have not moved beyond an initial identification of potential threats and have not examined them in depth or planned for specific risks. One area of weakness is the documentation of causal pathways linking exposures to health outcomes. This critical exercise underpins a state's ability to intervene effectively and protect the people or places most at risk. States have also made less progress in identifying the evidence-based interventions they can deploy to protect residents from the adverse health impacts of climate change. As seen in Table 10, states' collective performance on Indicator D3.2 was substantially weaker than it was for Indicator D3.1. It is not surprising that states' initial climate change efforts have focused on describing the likely impacts, as they come to terms with the scope of the threat. Successful adaptation, however, will require states to move quickly toward concrete responses.

Across all measures, leading states will play an important role in laying out a path for others to follow. These states will have done more than present a list of possible impacts; they will place global and regional trends within a local context in a way that prepares them to anticipate how climate change might affect the state and its people and to develop precise response plans.

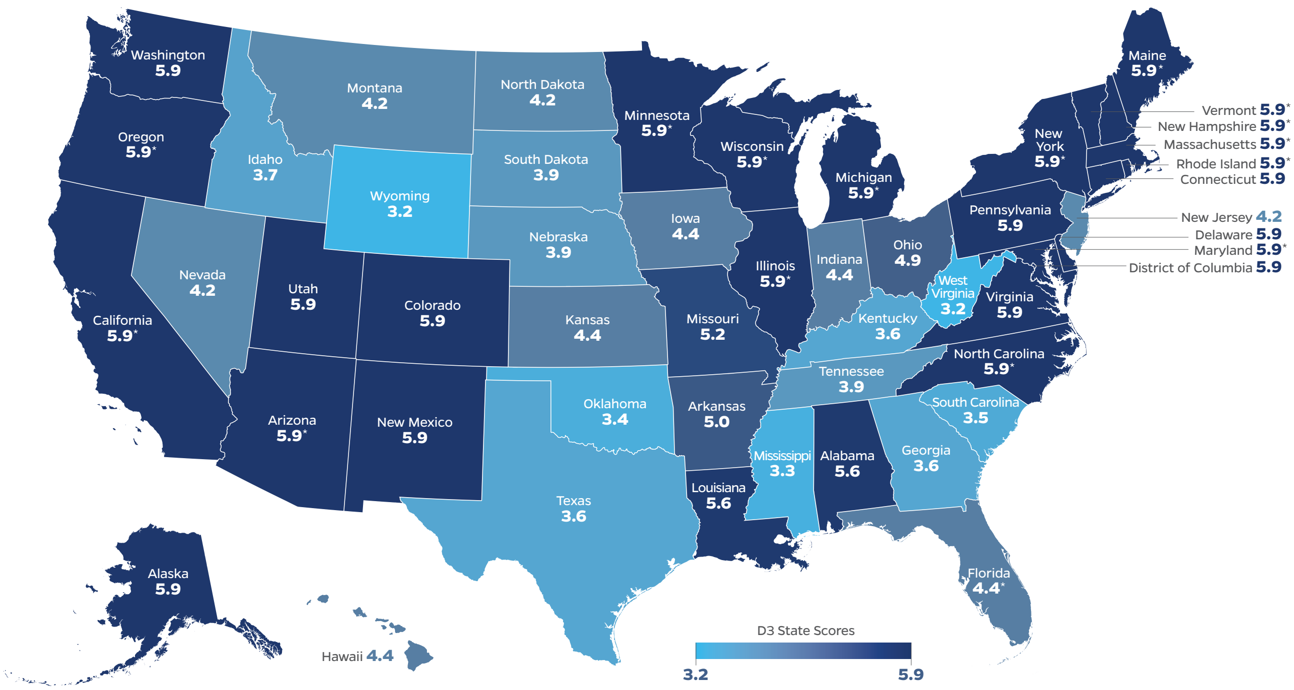
Table 10
State Performance on Domain 3, Measured by Completion of Each Sub-Indicator

	INDICATOR D3.1: Has the state assessed its vulnerability to the public health impacts of climate change?							INDICATOR D3.2: Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?	
	D3.1.1 Have climate-related exposures to the state been identified?	D3.1.2 Have climate-sensitive health outcomes been identified?	D3.1.3 Have risk factors for health outcomes been identified?	D3.1.4 Have causal pathways been developed for relevant climate-related hazards?	D3.1.5 Have climate projections at the state or state and local scale been reported?	D3.1.6 Have the most vulnerable populations in the state been identified and located?		D.3.2.1 Interventions identified	D.3.2.2 Interventions evidence-based
						D.3.1.6.1 Populations identified	D.3.1.6.2 Populations located		
Alabama	✓	✓	✓		✓	✓	✓	✓	✓
Alaska	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arizona	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arkansas	✓	✓	✓			✓		✓	✓
California	✓	✓	✓	✓	✓	✓	✓	✓	✓
Colorado	✓	✓	✓	✓	✓	✓	✓	✓	✓
Connecticut	✓	✓	✓	✓	✓	✓	✓	✓	✓
Delaware	✓	✓	✓	✓	✓	✓	✓	✓	✓
District of Columbia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Florida	✓	✓	✓	✓	✓	✓	✓		
Georgia	✓				✓	✓	✓		
Hawaii	✓	✓	✓	✓	✓	✓	✓		
Idaho	✓	✓			✓	✓			
Illinois	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indiana	✓	✓	✓	✓	✓	✓	✓		
Iowa	✓	✓	✓	✓	✓	✓	✓		
Kansas	✓	✓	✓	✓	✓	✓	✓		
Kentucky	✓				✓	✓	✓		
Louisiana	✓	✓		✓	✓	✓	✓	✓	✓
Maine	✓	✓	✓	✓	✓	✓	✓	✓	✓
Maryland	✓	✓	✓	✓	✓	✓	✓	✓	✓
Massachusetts	✓	✓	✓	✓	✓	✓	✓	✓	✓
Michigan	✓	✓	✓	✓	✓	✓	✓	✓	✓
Minnesota	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mississippi	✓	✓				✓			
Missouri	✓	✓	✓	✓	✓	✓	✓	✓	
Montana	✓	✓	✓		✓	✓	✓		
Nebraska	✓	✓			✓	✓	✓		
Nevada	✓	✓	✓		✓	✓	✓		
New Hampshire	✓	✓	✓	✓	✓	✓	✓	✓	✓
New Jersey	✓	✓	✓		✓	✓	✓		
New Mexico	✓	✓	✓	✓	✓	✓	✓	✓	✓
New York	✓	✓	✓	✓	✓	✓	✓	✓	✓
North Carolina	✓	✓	✓	✓	✓	✓	✓	✓	✓
North Dakota	✓	✓	✓		✓	✓	✓		
Ohio	✓			✓	✓			✓	✓
Oklahoma	✓				✓	✓			
Oregon	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pennsylvania	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rhode Island	✓	✓	✓	✓	✓	✓	✓	✓	✓
South Carolina	✓	✓				✓	✓		
South Dakota	✓	✓			✓	✓	✓		
Tennessee	✓	✓			✓	✓	✓		
Texas	✓				✓	✓	✓		
Utah	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vermont	✓	✓	✓	✓	✓	✓	✓	✓	✓
Virginia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Washington	✓	✓	✓	✓	✓	✓	✓	✓	✓
West Virginia	✓					✓	✓		
Wisconsin	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wyoming	✓					✓	✓		
Total	**51**	**44**	**37**	**33**	**46**	**50**	**46**	**30**	**29**

Figure 12 displays domain-wide state scores: 24 states and the District of Columbia earned a perfect score, reflecting a broad base of early progress in examining vulnerabilities and identifying interventions. Researchers found top-scoring states in most regions of the country (all except the Northern Great Plains and the Southern Great Plains), but there was a swath of states stretching diagonally across the country from Idaho and Montana southeast into Georgia and South Carolina that had greater room for improvement. The states that were furthest behind included Georgia, Kentucky, Mississippi, Oklahoma, South Carolina, Texas, West Virginia, and Wyoming. It is cause for concern that the residents of several of these states are also the most vulnerable to adverse health impacts from climate change.

Figure 12

Domain 3 State Scores



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater preparedness. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Grantees of the CDC's Climate-Ready States and Cities Initiative have an asterisk to the right of their score. Every grantee but Florida earned a perfect score.

Every state has identified at least one likely impact of climate change on its climate patterns and natural hazards (D3.1.1), and most states have projected those changes at a local level or contextualized interstate regional projections (D3.1.5). While it was common for states to have a climate action plan or other report (e.g., report from a governor's commission or advisory group) summarizing the expected effects, the state hazard-mitigation plan was the most common—and typically the most recent—source for this information. Many states have embraced FEMA's requirements, going beyond a single discussion of climate change to incorporate its effects or future trends into each hazard analysis.

Massachusetts has gone even further, fully integrating its hazard-mitigation and climate-adaptation planning into a single document and process in 2018.[275] Its approach could serve as a model for other states to address climate change more robustly through existing mechanisms. Previously, Massachusetts developed these two plans separately. The 2017–2018 process brought together a wide range of agency stakeholders, led jointly by the state's Executive Office of Energy and Environmental Affairs, the Executive Office of Public Safety and Security, and the Massachusetts Emergency Management Agency. To conduct its risk assessment, the plan incorporates the findings of nearly 80 climate change vulnerability assessments conducted by state agencies.[276] The assessment looks at impacts across five dimensions: (1) populations, (2) government, (3) built environment, (4) natural resources and environment, and (5) economy. The plan addresses 14 natural hazards through the lens of four projected climate changes: (1) changes in precipitation, (2) sea-level rise, (3) rising temperatures, and (4) extreme weather. (See Figure 13.) Climate change adaptation is a facet of hazard mitigation; as such, the report defines both as: "A specific action, project, activity, or process taken to reduce or eliminate long-term risk to people, property, and natural systems from climate change and/or natural hazards and their impacts."[277] Establishing this relationship provides a familiar framework for a relatively new area of focus and allows the state to leverage limited resources to achieve multiple goals. In the spirit of BRACE, Massachusetts refers to the plan as a living document that will be continually reviewed and revised during its five-year lifespan.[278]

Figure 13

Massachusetts's Climate Change and Natural Hazard Taxonomy

PRIMARY CLIMATE CHANGE INTERACTION	NATURAL HAZARD	OTHER CLIMATE CHANGE INTERACTIONS	REPRESENTATIVE CLIMATE CHANGE IMPACTS
Changes in Precipitation	Inland Flooding	Extreme Weather	Flash flooding, urban flooding, drainage system impacts (natural and human-made), lack of groundwater recharge, impacts to drinking water supply, public health impacts from mold and worsened indoor air quality, vector-borne diseases from stagnant water, episodic drought, changes in snow-rain ratios, changes in extent and duration of snow cover, degradation of stream channels and wetland
	Drought	Rising Temperatures, Extreme Weather	
	Landslide	Rising Temperatures, Extreme Weather	
Sea Level Rise	Coastal Flooding	Extreme Weather	Increase in tidal and coastal floods, storm surge, coastal erosion, marsh migration, inundation of coastal and marine ecosystems, loss and subsidence of wetlands
	Coastal Erosion	Changes in Precipitation, Extreme Precipitation	
	Tsunami	Rising Temperatures	
Rising Temperatures	Average/Extreme Temperatures	Not Applicable (N/A)	Shifting in seasons (longer summer, early spring, including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, ecosystem stress, energy brownouts from higher energy demands, more intense heat waves, public health impacts from high heat exposure and poor outdoor air quality, drying of streams and wetlands, eutrophication of lakes and ponds
	Wildfires	Changes in Precipitation	
	Invasive Species	Changes in Precipitation, Extreme Weather	
Extreme Weather	Hurricanes/ Tropical Storms	Rising Temperatures, Changes in Precipitation	Increase in frequency and intensity of extreme weather events, resulting in greater damage to natural resources, property, and infrastructure, as well as increased potential for loss of life
	Severe Winter Storm/ Nor'easter	Rising Temperatures, Changes in Precipitation	
	Tornadoes	Rising Temperatures, Changes in Precipitation	
	Other Severe Weather (Including Strong Wind and Extreme Precipitation)	Rising Temperatures, Changes in Precipitation	
Non-Climate Influenced Hazards	Earthquake	N/A	There is no established correlation between climate change and this hazard

Source: Massachusetts Emergency Management Agency and Executive Office of Energy and Environmental Affairs[279]

In addition to broadly recognizing the threat of climate change, most states acknowledge that climate change will have an effect on public health, and most have identified at least one likely health outcome (D3.1.2). One of the most commonly discussed health threats is heat-related illness and death. There is good reason for this: extreme heat is responsible for more deaths in the United States than any other weather-related hazard, including natural disasters such as hurricanes and tornadoes.[280] Many states reported having robust plans and programs to address heat emergencies. Higher temperatures and prolonged heat waves are also a more easily recognized effect of climate change. States also frequently cited vector-borne diseases and respiratory issues, including allergies and asthma, related to changes in air quality from higher temperatures or wildfire smoke.

The state of Washington stands out by segmenting health implications into three categories: (1) increased morbidity, (2) impacts to health and safety protections, and (3) exacerbated health disparities in its state health assessment.[281] It outlines specific risks to health and safety, including those related to heat, infectious conditions, allergies, respiratory and cardiovascular illness, and mental health, as well as disruptions caused by natural disasters. And the state highlights the fact that populations at greatest risk already carry a disproportionate burden of disease, necessitating adaptive actions that vary by location and community.

Fewer states documented deeper-level analyses of how climate-related health threats will impact specific segments of their population. Understanding the specific risk factors in a community is an important part of this process (D3.1.3). Surveillance and epidemiological investigations can help states identify patterns in terms of who experiences certain health outcomes, as well as when and where they do. For example, Maryland used state-specific data to develop a baseline health assessment and to identify risk factors that were then used, along with climate projections, to model current and future climate-related health impacts across the state and in four pilot counties. A report commissioned by the state notes: “The impacts of climate change on human health will vary and depend on, among other factors, an individual’s sensitivity and exposure to a given threat and the capacity to adapt. … Preventative actions are dependent on Maryland’s capacity to track current disease patterns and project future threats to human health.”[282]

The broader definition used for vulnerability (D3.1.6) may help explain why states overall did not perform as well on D3.1.3, which asked whether the state had identified risk factors for climate-related health outcomes. While most states have some process for identifying—and, to a slightly lesser extent, locating—populations that are vulnerable to environmental hazards and natural disasters, fewer states are planning around specific climate-related health outcomes. States that devoted more than a passing glance to risk factors also often presented information as part of a comprehensive discussion of the health outcome(s) and relevant causal pathway(s).

Just under two-thirds of states presented a causal pathway (D3.1.4). These pathways provide a rationale for climate and health interventions, and indicate that states have studied in detail their changing exposures and the associated risks posed for specific populations. States that scored higher overall were more likely to frame their work using complex and multifaceted pathways. (See Figure 14.)

In its 2014 Climate and Health Profile Report, Oregon devoted a whole section to describing causal pathways related to the state's projected climate changes.[283] The state outlines pathways for eight key threats: (1) heat, (2) drought, (3) wildfire, (4) floods and storms, (5) sea-level [rise], (6) allergens, (7) infectious disease, and (8) indirect impacts. The pathways are evidence-based and used as a framework for discussing not only potential health outcomes but also the relevant risk factors and vulnerable populations. As part of the pathway linking heat to illness or death, for example, Oregon addressed direct effects of temperature exposure, as well as violence, air pollution, harmful algal blooms, and recreational risk. The state further broke down heat-related death into immediate causes, such as heart attack, stroke, renal failure, heat stroke, and respiratory illness. Oregon identifies those who are vulnerable to heat-related deaths as people with chronic health conditions such as cardiovascular disease, infants and children, older adults, people with low income, people who are socially isolated, city dwellers, and outdoor workers—a list that accounts for variations in sensitivity, exposure, and adaptive capacity. The state has focused on social factors in locating its most vulnerable census tracts, while acknowledging that it should integrate additional measures of climate-related exposures and adaptive capacity into future assessments.[284,285]

Figure 14
Oregon's Climate Change Causal Pathway

Source: Oregon Health Authority, Public Health Division[286]

Utah has prepared a report that specifically addresses the state-level public health risks posed by climate change.[287] This document reflects the Utah Department of Health's analysis of the risks and its efforts to minimize the impacts on Utahans. The causal pathways presented in the document may be helpful for other Western states that want to build on existing climate change work related to drought, wildfire, or natural resource management. The health department is the only state agency that has undertaken this type of assessment, but there are signs that the state is moving toward broader action. In its 2019 hazard-mitigation plan, Utah's Division of Emergency Management recommended the state require a comprehensive climate change assessment to pave the way for identifying specific and meaningful adaptation and mitigation actions.[288] Later that year, the Utah legislature asked the University of Utah to identify policy options that would reduce air pollution and address the causes and impacts of climate change; the final and positively received report encourages policymakers to follow the lead of other states and "adopt a Utah-style changing climate action plan."[289] If the state moves forward with this work, there is an opportunity for the health department to play a leadership role in developing those wider plans.

Similarly, Alaska conducted a health-impact assessment on climate change in the state and used the findings from that report to develop recommendations for the governor's climate change action plan.[290] As part of its assessment, the state provided a framework to help local communities use the information to prioritize adaptation strategies and plan for resource needs. The state suggested that prioritization criteria might include: (1) potential time to impact, (2) geographic extent of the impact, (3) the number of people directly impacted, (4) the number of people impacted who could experience serious health issues, and (5) the resources required to adapt to the impact.[291] (See Figure 15.)

Figure 15

Alaska's Example of a System to Rank the Timing and Magnitude of Health Impacts

Health Effect Category	Selected Adverse Health Impacts	Time to Impact	Geographic Extent	# of People Directly Impacted	# of People Experiencing Serious Health Problems	Resources Needed to Adapt/ Respond
Mental Health and Wellbeing	Increase in solastalgia, anxiety, and depression due to the changing environment	< 20 years	Statewide	Many	Intermediate	Intermediate
Accidents and Injuries	Increased heat stress and associated disorders	20-50 years	Local	Few	Few	Few
	Increased accidents/injuries due to infrastructure damage	< 20 years	Regional	Few	Few	Intermediate
	Increased accidents/injuries due to wildfires	< 20 years	Regional	Few	Few	Intermediate
	Increased accidents/injuries due to extreme weather events (e.g., flooding)	< 20 years	Regional	Intermediate	Intermediate	Intermediate
	Increased accidents/injuries due to unsafe ice conditions	< 20 years	Regional	Few	Few	Few
Exposure to Potentially Hazardous Materials	Increased cardiovascular disease morbidity/mortality due to air pollution (e.g., caused by wildfires)	20-50 years	Regional	Few	Few	Few
	Increased respiratory disease mobidity/mortality due to air pollution (e.g., caused by wildfires)	20-50 years	Regional	Few	Few	Few
	Increased exposure to hazardous materials (e.g., due to infrastructure damage, storm events)	< 20 years	Regional	Few	Few	Intermediate
Food, Nutrition, and Subsistence Activity	Decrease in subsistence food consumption and food security (e.g., due to migration changes, increased costs of importing foods)	20-50 years	Regional	Intermediate	Intermediate	Intermediate
Infectious Diseases and Toxins from Microorganisms	Increased morbidity/mortality related to vectorborne diseases	20-50 years	Regional	Intermediate	Few	Intermediate
	Increased morbidity/mortality related to zoonotic diseases	20-50 years	Regional	Few	Few	Few
	Increased morbidity/mortality related to food- and waterborne diseases (e.g., botulism, PSP, *Vibrio parahaemolyticus*)	< 20 years	Regional	Few	Few	Few
Non-communicable and Chronic Diseases	Increased rates of chronic diseases such as obesity, diabetes, and hyperlipidemia due to changing lifestyles	20-50 years	Local	Few	Few	Few
	Increased rates of chronic respiratory diseases due to aeroallergens	20-50 years	Regional	Few	Few	Few
Water and Sanitation	Increased morbidity/mortality due to compromised access to water and sanitation facilites (e.g., infrastructure damage)	< 20 years	Regional	Few	Few	Intermediate
Health Services Infrastructure and Capacity	Increased morbidity/mortality due to compromised access to health care (e.g., infrastructure damage)	20-50 years	Regional	Few	Few	Intermediate

Note: The state cautions that this table was constructed as a notional example for Alaska communities to consider replicating when developing the community health component of their own climate change adaptation plans. It is primarily an instructional tool rather than a precise representation of the likelihood of specific health impacts due to climate change in Alaska.

Source: Alaska Department of Health and Social Services[292]

Many states have formally identified and located their most vulnerable residents (D3.1.6), typically applying either the CDC's Social Vulnerability Index, which uses 15 U.S. Census variables to help local officials identify communities that may need support in preparing for hazards or recovering from disaster, or one designed by the Hazards and Vulnerability Research Institute at the University of South Carolina, which synthesizes 29 socioeconomic variables to characterize vulnerability to environmental hazards at the county level.[293,294] While these tools do not explicitly consider climate change, they examine the types of hazards and vulnerabilities that climate change is likely to amplify.

However, states may not recognize this connection, and indeed some states mapped one of the social vulnerability indexes but did not explicitly address climate change or climate-related health outcomes. Few states reported on vulnerability driven by climate change in a comprehensive way, encompassing environmental, social, and demographic factors and projected future trends. Considering all such factors produces more useful data for planning—especially if data are based not just on past observations but also projections of future risk—and does not necessarily require complex analyses.

For example, California, Minnesota, and South Carolina are three states that have presented composite data in such a layered fashion. (See Figure 16.) While the basic concept is the same in all three states, each one has tailored it to their own purposes. A state may inform its approach with practical considerations, such as the availability of data, staffing resources and expertise, or the priorities of the agency leading the analysis; the approach may also reflect an examination of the particular characteristics that influence vulnerability (broadly or specific to certain hazards or outcomes) in the state.

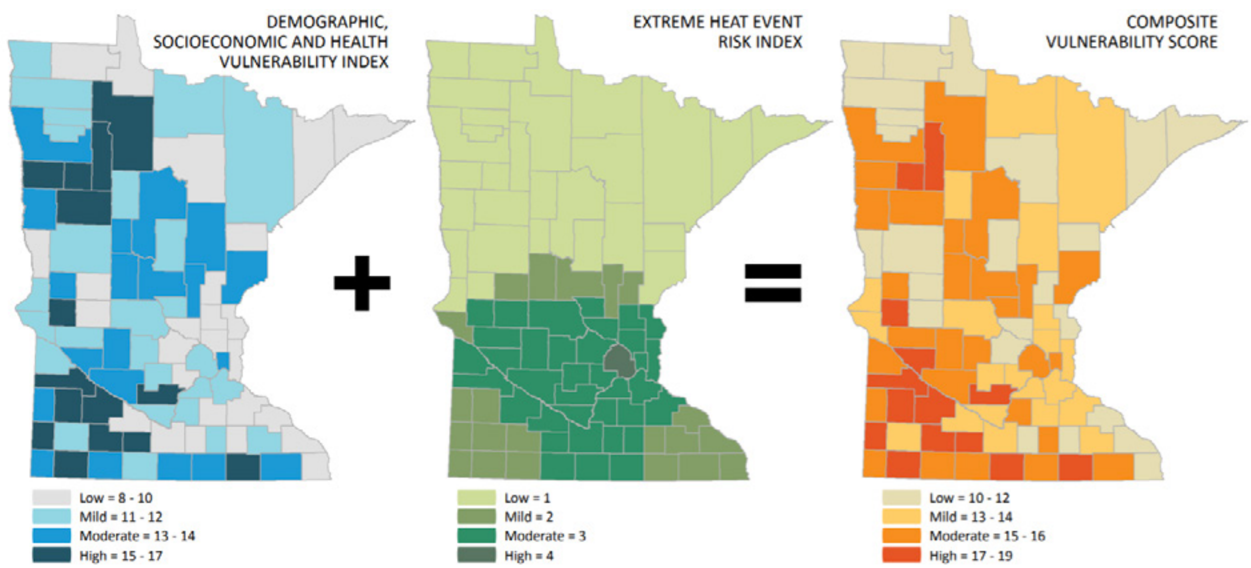
Minnesota began by conducting a review of existing literature on climate change indicators and vulnerable populations.[295] The Minnesota Department of Health used this review to develop a master list of indicators, which it split into four categories: (1) climate hazard, (2) health risk, (3) population vulnerability, and (4) built-environment hazard. Using these indicators and the Association of State and Territorial Health Officials (ASTHO) Climate Change Population Vulnerability Screening Tool, the health department developed a vulnerability index and county-level composite maps for three climate-related hazards: (1) extreme heat events, (2) air pollution, and (3) flooding. Each index uses a different set of population vulnerability indicators, reflecting the causal pathways and risk factors specific to that hazard and specific to Minnesota.

Other states have taken a simpler approach, drawing on existing tools like the indices mentioned above. In its hazard-mitigation plan, South Carolina depicted overall and hazard-specific vulnerability by mapping data on hazard risk blended with data from the University of South Carolina's Social Vulnerability Index.[296,297] Hazard risk incorporated data on past events and associated losses (property damage, crop damage, deaths, and injuries). The state also looked at how social factors had changed over recent years, but the assessment did not project future changes.

Some states provide their vulnerability data through a dashboard or tool that local health departments and other stakeholders can use to create their own maps or to conduct analyses. For example, through the CalBRACE program, California offers CCHVIz, an online data-visualization platform for its Climate Change & Health Vulnerability Indicators. Data are provided for 18 indicators across three categories: (1) environmental exposures, (2) population sensitivity, and (3) adaptive capacity.[298] It is one of few states that has incorporated climate projections into its vulnerability assessments, although projected estimates are only available for certain exposures (e.g., extreme heat, sea-level rise).[299] The CCHVIz website includes step-by-step guidance on how to use the platform to understand and map the main types of vulnerability in a specific county, as well as resources on how to begin acting on the information.[300]

Figure 16

Minnesota's Population Vulnerability, Extreme Heat Event Risk, and Composite Health Vulnerability Maps



Source: Minnesota Department of Health[301]

Of course, historical data alone can still be instructive. Observing wide variation in the association between certain climate-related exposures and health impacts in different parts of the state, New York has used its findings, combined with other scientific literature, to identify population, social, and environmental factors that might contribute to individual- and neighborhood-level vulnerability.[302] For heat, these factors were used to develop a composite vulnerability index, which was validated against state data on related health outcomes.[303,304] New York has used this information to create Heat and Health Profile Reports for each county to help them plan and allocate resources for heat-related illness.[305] For example, the Heat Vulnerability Index can inform county officials about where to set up cooling centers or how to arrange home visits to elderly residents living alone.[306]

While tools like the social vulnerability indexes created by the CDC or the University of South Carolina are designed to be broadly applicable, state and local characteristics determine the salience of specific factors, particularly those related to adaptive capacity. The better a state parses the drivers of vulnerability among its residents, the more effectively it can prepare for and prevent the related negative health impacts among those groups. New York's Heat Vulnerability Index draws on 13 measures across four categories: (1) language vulnerability, (2) socioeconomic vulnerability, (3) environmental and urban vulnerability, and (4) elderly isolation and elderly vulnerability.[307] Vermont's index draws on 17 measures, organized around six themes: (1) population, (2) socioeconomic, (3) health, (4) environmental, (5) climate, and (6) heat illness.[308] Both present valuable information that can guide communities and state officials in developing and implementing life-saving interventions.

PERFORMANCE OF CDC'S CLIMATE-READY STATES AND CITIES INITIATIVE GRANTEES

States that had received funding from the CDC's Climate-Ready States and Cities Initiative as of the time of this analysis were generally among those that were furthest along in the process of assessing their specific vulnerabilities and preparing to adapt, scoring highest in the assessment (all but Florida earned a perfect score) and demonstrating reporting that was characteristically methodical and comprehensive. Many grantees have prioritized the health impacts of greatest concern to the state, enabling them to effectively plan and implement meaningful interventions. They also tended to transparently lay out work left to be done, explicitly identifying limitations and next steps.

Nearly all grantees had started to identify interventions that could protect their residents from the public health impacts of climate change. Three-quarters of these states had a written plan or strategy that specifically focused on steps they would take to adapt to climate change; nationwide, fewer than half of states had produced such a document. Existing adaptation plans are not necessarily specific to health, but they represent an important step toward action. In one of its earliest reports on adaptation, Maine noted that, "the very process of adaptation *planning* results in enhanced adaptation *capacity* across a range of actions."[309]

Once states have identified climate-related hazards and climate-related health outcomes, they can begin preparing for them. The second primary indicator used for this assessment looks at how states are planning to adapt to climate change. Worryingly, given fast-approaching threats, fewer states (30) had reached this stage.

Most states that have started to identify potential interventions did so in a tentative way, listing options or compiling recommendations for state agencies or future working groups to consider. Indeed, it was common for recommendations to acknowledge, at least tacitly, a state's beginner status by calling for training or the raising of awareness, among both state employees and the public. To earn credit for this indicator, states had to identify strategies that addressed the plausible public health impacts of climate-

related hazards. In many cases, the health department or a health-focused working group compiled these recommendations, but states also identified health-related recommendations in broader climate change commission reports and action plans or in their hazard-mitigation plans. Less often, plans from other sectors, such as water resource management, discussed adaptation strategies that would protect human health.

A common approach was to consider climate change efforts in relation to existing public health capabilities, with recommendations that focused on capacity building or expanding to incorporate climate-related issues. States often presented disease surveillance and environmental monitoring as tools to guide interventions and future programming. Many states already have programs in place for monitoring climate-related exposures—such as temperature and air and water quality—and alerting the public when the exposures reach unsafe levels. These thresholds can provide guidance for individual behavior changes and they can activate other community resources. Deploying such existing programs and resources effectively can help communities affordably avoid some of the adverse health effects of climate change. Data from these programs can also provide a foundation for other adaptation efforts and help public health departments understand whether existing interventions are reaching the right populations at the right time. New Hampshire described using real-time hospital data to track heat-injury admissions, especially among vulnerable populations; this information helps officials decide whether to open cooling centers.[310] New Mexico was planning to build on its emergency weather risk communication programs by engaging local emergency managers to coordinate and strengthen their response to these events.[311]

Frequently, states identified interventions that could address specific climate-related hazards; for example, many discussed the use of cooling centers and air conditioning as an adaptive strategy for extreme heat. Others took a broader approach, presenting cross-cutting strategies that could address all or multiple hazards.

In nearly all cases, the identified interventions were supported by at least some evidence. Rhode Island, for instance, compiled best practices from other states. A few states have begun piloting or evaluating specific strategies. For example, in an addendum to its climate- and health-adaptation plan, Arizona described the progress of successful or promising county-level interventions.[312]

Some states used their vulnerability assessments to steer interventions to people or places with the greatest need. States often focus on vulnerable populations in their efforts to reduce the health impacts of extreme heat. Many states highlighted the greater needs of people who are elderly or socially isolated, residents who do not have or cannot afford to use air conditioning at home, and neighborhoods with a lot of pavement and little tree cover or green space. For example, the Vermont Department of Health partnered with the state's Urban & Community Forestry Program to provide 500 trees to residents in four communities that were identified as high-risk using the Vermont Heat Vulnerability Index, which includes a lack of tree cover as a key risk factor for heat-related illness.[313]

Some states were pushing for the integration of adaptation throughout the health department's portfolio. Washington's climate strategy called for climate adaptation to be "a standard part of agency planning" across all state agencies.[314] The Minnesota Department of Health's Climate & Health Program leads an agency-wide working group with the explicit goal of fully integrating climate change adaptation throughout the agency's work.[315] Every five years, the program surveys staff to assess their knowledge and opinions on climate and health.[316] One of their first interventions was to develop regional climate and health data profiles to help emergency managers and emergency preparedness professionals understand and use climate projection data for planning.[317]

Like Massachusetts, Minnesota is one of a small group of states that explicitly recognizes climate change adaptation as a variant of hazard mitigation focused on future conditions, rather than historical ones.[318] Recognizing this intersection also acknowledges the multi-sectoral nature of adaptation. States often pointed out that relevant interventions do not always fall under the purview of health departments and emphasized the importance of partnerships across agencies and external stakeholders. For instance, the New York State Department of Health "integrat[es] climate change as a determinant of health into all relevant public health programs and services including other agencies."[319]

Some states were looking at ways to leverage other efforts, including climate change mitigation activities, to achieve human health goals of adaptation. For example, California found that shifting to active transportation (walking and biking) decreased greenhouse gas emissions and reduced the burden of cardiovascular disease and diabetes, both of which can increase vulnerability to climate-related hazards.[320] Other examples include green infrastructure, energy-efficient housing, and zoning and land-use policy.[321] Recognizing health co-benefits can improve cost-benefit calculations and help decision-makers understand the full impact of policies and programs. Another way that states (e.g., Alaska, Massachusetts, Michigan, Vermont) are evaluating the climate and health implications of their plans, policies, and programs is by using health impact assessments to identify the potential health effects of actions across sectors, as well as to identify how impacts might disproportionately affect various groups and influence health outcomes.[322,323,324,325,326]

PROGRAM AND POLICY RECOMMENDATIONS

This report has documented the scientific certainty that Earth's climate is changing and that the United States can expect major health impacts as a result. To that end, states have shown areas of progress and areas that demand improvement with respect to the nation's readiness to effectively adapt. Protecting people, particularly those who are most vulnerable, must be treated everywhere as a critical public health priority necessitating swift, concrete, and persistent action. The planet reminds us of this urgency on a near-constant basis.

The program and policy recommendations outlined below can help guide this work. Just as adaptation was the focus of this assessment, it is also the orientation of these recommendations. As the USGCRP has warned, major reductions in greenhouse gas emissions (mitigation) are necessary to limit global temperature increases. Critically, such actions would soften the magnitude and intensity of climate change and its impacts, but the United States must make progress on parallel and complementary tracks (mitigation and adaptation), as each are essential to minimizing harmful consequences.

In addition to the results of this assessment, these recommendations were further informed by interviews that researchers conducted with experts, including those on the front lines, as well as a review of published literature. The recommendations are divided into two segments—federal and state—based on the respective roles of policymakers and other officials at each level, but close coordination between all levels, including localities, territories, and tribes, is essential for success.

FEDERAL RECOMMENDATIONS

States rely on the federal government for guidance and coordination. The United States must develop and implement a national plan to address the health impacts of climate change—in addition to other related effects—including by enacting a law that would ensure a measure of attention from relevant agencies. But laws will not be enough; Congress also needs to appropriate funds to strengthen the evidence base behind adaptation interventions and their implementation, and to ensure that every state health department can prepare for climate change and track its progress through local-level monitoring. And the country must rebuild its public health infrastructure and workforce, a necessity with benefits that transcend discrete health threats.

1. **Enact legislation requiring a national strategic plan.**
   The United States urgently needs a strategic action plan to address the health impacts of climate change. Legislation should be enacted requiring the U.S. Department of Health and Human Services to develop such a plan and to fund development and ongoing maintenance of health system capacity specifically for this purpose.

The Climate Change Health Protection and Promotion Act of 2019, which requires the creation of such a plan, provides a valuable starting point for legislation that could address the concerns presented in this report.[327] It mandates that federal agencies engage in forecasting and modeling, and that they track both environmental and disease data, expanding an understanding of the relationship between climate change and health outcomes. Importantly, the bill explicitly recognizes that "climate change disproportionately impacts communities of color and low-income communities," and it calls for the federal government to use all practicable climate-related means and measures to improve health equity, including by prioritizing such communities in the plan and by requiring the inclusion of people with "practical or lived experience with relevant issues" in a newly formed science advisory board.

2. **Fully fund the CDC's Climate and Health program.**
   Congress and the CDC should ensure sufficient funding to support every state, locality, U.S. territory, and tribe that wishes to become a Climate-Ready States & Cities Initiative (CRSCI) grantee. Through training and other technical assistance, CRSCI helps grantees use the five-step Building Resilience Against Climate Effects (BRACE) framework to identify likely climate impacts in their communities, potential health effects, and their most at-risk populations and locations. Additional funding should also enable the CDC to bolster its guidance on evidence-based adaptation interventions.

   Importantly, the CDC's Climate and Health Program is part of a broader array of critical preparedness programs, including the CDC's Public Health Preparedness Program, the Office of the Assistant Secretary for Preparedness and Response's Hospital Preparedness Program, and grants to states made by FEMA and the EPA.

3. **Provide funding for adaptation research and scientific training.**
   Federal priorities should include research funding via the National Institutes of Health or other agencies for academic centers of excellence, training of skilled researchers, and educational programming conducted by academic institutions. Research should study the effectiveness of promising interventions and risk-reduction initiatives in order to advance implementation science. These efforts would help build a full-fledged, evidence-based climate adaptation program to protect health.

4. **Fully fund the CDC's National Environmental Public Health Tracking Network.**
   This program works with a network of partners to collect, integrate, and analyze disease and environmental data to help public health and other practitioners identify and target health risks. The agency's Climate and Health Program and Tracking Network collaborate often, with mutual benefits, including the provision of climate data. But the CDC is only able to fund participation in the Tracking Network for about half the states, many of which are already using the data to support their climate and health work.[328] The CDC has estimated that it needs roughly $75 million to expand the program to all 50 states, the District of Columbia, and U.S. territories. Additional funding, alongside technical improvements to make reporting as smooth and straightforward as possible, would also allow the program to expand the type of health data available to policymakers, public health professionals, and the public.

5. **Strengthen the public health infrastructure and workforce, including by modernizing data and surveillance capacities.**
   Public health and climate change work relies on good data that is comprehensive, comparable across jurisdictions, near real-time, and granular enough to allow for disaggregation by key factors of vulnerability (e.g., income, race, age, disability status, etc.). The nation needs mechanisms to collect these data to ensure they are being critically analyzed and used to drive policy. Federal leaders should establish a Core Public Health Infrastructure Program at the CDC, awarding grants to state, local, tribal, and territorial health departments to ensure they have the tools, highly trained workforce, and systems in place to address existing and emerging health threats. A critical imperative is filling the gap in relevant data on American Indian and Alaska Native tribal nations and U.S. territories, a priority made even more important by the acute threat that climate change poses to many of their residents.

6. **Prioritize equity and resilience by supporting and protecting high-risk populations, and by addressing the social determinants of health.**
   As this report has documented, the health impacts of climate change will not be felt equally. Some people, owing to a mix of environmental, social, and demographic factors, will bear a disproportionate burden. Therefore, all relevant federal policies, programs, and funding must maintain a constant focus on the identification of these areas and people, and persistently intervene to reduce vulnerability and work side by side with high-risk groups to protect their health and safety.

   Governments at all levels should direct funding to programs that address the social determinants of health—factors that improve the conditions in people's lives and that impact their health and resilience. The CDC and other federal agencies should be funded to address social determinants through cross-sector collaboration, policy change, and community partnerships. One concrete step would be enacting the Improving Social Determinants of Health Act of 2020, which would create a program at the CDC to provide capacity-building grants to public health departments, community organizations, nonprofit organizations, and institutions of higher education.[329]

STATE RECOMMENDATIONS

No state earned a perfect score across all indicators tracked for this analysis. All states need to better invest in public health and emergency management preparedness; engage in deeper-level adaptation planning, guided by the CDC's BRACE framework; dedicate resources to preparing for the health impacts of climate change; and partner with others to bring about better outcomes.

1. **Bolster states' core public health preparedness capabilities.**
   State decision-makers—from governors to legislators to agency directors—must adequately fund core public health functions, including surveillance and epidemiological investigation capabilities, environmental monitoring, incident and information management, and healthcare readiness. Moreover, they must strengthen collaboration across stakeholders and work to earn public trust and build social cohesion, essential intangibles of effective preparedness.

2. **Build health equity leadership in state and local governments.**
   All state and local governments, including health departments, should build up internal infrastructure to drive equity, including identifying a chief health equity or health resilience officer. Health equity and emergency preparedness officials should work across programs to incorporate equity issues and goals into preparedness policies and plans, improve staff understanding of how the legacies of structural and systemic racism affect disaster resilience and recovery, and collect and leverage data to identify unique community assets and advance equity on an ongoing basis.[330]

3. **Complete all steps of the CDC's BRACE framework, and continuously work to enhance and refine preparations.**
   State agencies must conduct and facilitate rigorous vulnerability assessments at the state and local levels. The assessments should focus especially on populations at highest risk and the health threats most pertinent to them. States must also push ahead to complete all steps of the framework, including identifying and implementing evidence-based interventions to protect residents. Finally, as agencies implement interventions, they should continually evaluate effectiveness, and strive for quality improvement.

4. **Establish ongoing, dedicated funding and staff for climate-related preparations.**
   Given the many competing demands on the public health workforce, health departments must designate at least one staff person to dedicate their time to preparing for and responding to climate change. Climate change preparations, however, do not just need to happen in health departments; agencies such as environmental and emergency management departments should designate similar positions. All these individuals should coordinate with each other across the state via regular meetings and common goals. To ensure accountability, climate change work should appear in the position descriptions and be part of these employees' annual review process. Goals for these positions should be specific, measurable, achievable, results-oriented, and time-bound.

5. **Engage in close coordination with local and federal partners.**
   Given the complex natures of both the climate and health, creating and funding positions at one level of government is not enough. Those on the front lines must drive planning and implementation at the state level. Where possible, state health departments should provide mechanisms for regular communication with local departments and tribal nations. This might take the form of calls or meetings. Similarly, state-level needs and successes must inform what happens at the federal level. State health departments should work with the Association of State and Territorial Health Officials to ensure agencies such as the CDC, EPA, and FEMA are aware of state needs.

6. **Plan with communities, not for them.**
   Preparedness officials must include members of communities at greatest risk—and compensate them for their involvement, when appropriate—in planning and decision-making. Health departments and emergency management agencies should rely on the expertise of those who may bear a disproportionate risk, such as older adults, people with disabilities, and individuals with chronic health conditions, to ensure plans and procedures meet the needs of everyone. Community-driven planning strengthens resilience, as residents play a lead role in defining the challenges they face and the solutions most relevant to their unique circumstances.

CONCLUSION

"What's at stake here is a livable world."[331] That was how a leading climate scientist summed up the cataclysmic levels of species extinction brought about by climate change, but the sentiment also succinctly captures the urgency of adequately addressing its impacts on human health. The essential question remains: Will humanity take the necessary actions to ensure that over the long-term people, regardless of their station or circumstances, can live healthful lives on the only planet available to them? At present, the answer is unclear.

This report makes the case that public health preparedness is vitally important, a lesson that tends to be relearned with every predicted emergency. This means, in part, preparations to safely adapt to longstanding threats—threats that climate change will turbocharge. It means preparing to protect people, particularly those who are most vulnerable, as heat waves get hotter and longer; severe storms break records year after year; wildfires outmatch traditional methods of control; pollution and contaminants increasingly endanger the quality of the air and water; pests bring disease and threaten staple foods; and the trauma of it all tests mental health. All of this must happen even as the nation pushes for stronger mitigation efforts, essential for ensuring that adaptation efforts are not overwhelmed, to avert worst-case scenarios.

The good news is that the nation's public health leaders have charted at least a partial pathway for officials to follow. The CDC's BRACE framework provides clear and precise guidance for state, local, tribal, and territorial governments. Its straightforward five-step cycle moves from assessing and understanding vulnerabilities and potential impacts to identifying and implementing adaptive interventions to continuous evaluation and improvement. With the requisite prioritization and support from leaders at all levels of government, every state and sizeable locality in the country is capable of employing a version of the framework—a step that would significantly improve the health security of residents. While this study found that every state has documented some preparations to protect its people from climate change's health impacts, it also found significant room for improvement, particularly in many of the places at greatest risk.

At the same time, federal partners play an indispensable role and must do more to guide, assist, and support states and localities. This will be a long-term project, but immediate actions that would make a meaningful difference include legislation requiring the U.S. Department of Health and Human Services, including the CDC, to elevate, expand, and strengthen climate-related preparedness, as well as targeted funding for environmental health tracking and public health infrastructure and data modernization. The more robust this country's public health system becomes, the safer Americans will be from a whole host of threats, including climate change.

Humanity faces an unprecedented challenge. Nothing less than the viability of life on Earth demands that nations move with urgency to address it. We know much of what we need to do; and we are capable of doing it. It is past time to summon the necessary will and seriousness of purpose.

APPENDIX A: METHODOLOGY

This appendix describes the process used to scope and conceptualize the research for this project; fashion and refine indicators of climate-related vulnerability and preparedness; collect, normalize, and code credible data to support the indicators; and calculate scores to assess states' preparedness vis-à-vis vulnerability.

PROJECT SCOPING AND INFORMATION GATHERING

This project sought to answer four sequential research questions.

1. What, if any, are the direct and indirect health impacts—positive and negative—of climate change on U.S. residents, and how are those impacts expected to change over time?

    a. How do these impacts, and how will these impacts, vary by state or region?
    b. How do these impacts, and how will these impacts, vary by population or community?
    c. Do these impacts represent new threats, or is climate change accelerating and intensifying preexisting threats—or both?

2. Besides measures to mitigate the nature and extent of future climate change, what adaptive preparations, if any, could be made to protect residents from the health risks posed by climate change? How, if at all, should preparations vary by state or region?

Researchers did not engage in original research to answer these first two questions. Rather, they relied on a robust and growing body of credible literature, as well as on interviews with issue experts.

3. How should states' preparedness be tested or measured? How, if at all, should tests or measures vary by state or region?

4. To what extent are states prepared to protect their residents from the public health impacts of climate change? How should lessons learned from leading states be applied to those with greater room for improvement?

Researchers sought to answer the third and fourth questions through a mix of secondary and original research. That is, they used the information gathered through the exploration of the first two questions to inform a set of indicators, and, ultimately, an assessment.

In the first stage of the project, researchers laid the groundwork by gathering information on the connections between climate change and public health, reviewing past work that might serve as models to inform the project, and exploring how to conceptualize preparedness for climate-related health impacts. Researchers relied principally on three sources of information: expert interviews, an academic literature review, and a grey literature review.

1. **Expert interviews.** Researchers conducted structured interviews with a diverse group of subject-matter experts to learn about their work and how to best approach this project. Standard topics included key research and other literature, essential elements of preparedness and the factors on which they depend, best practices in the area of climate-related adaptation and how those practices are facilitated or impeded, and reviews of states or localities seen as leaders in this area.

   These discussions produced a wealth of useful information. In particular, three common themes emerged:

   a. **Near-term focus**. Advisors urged states—and therefore researchers for this project—to focus principally on the near-term (e.g., five to 10 years). They argued that a good indication of how states will fare when more intense impacts arrive in 2050 is how they cope with milder impacts in 2025.

   b. **Preparedness and vulnerability.** Advisors argued that it would be incomplete to measure preparedness without also assessing vulnerability (i.e., environmental, social, and demographic factors), as the two are inextricably linked. For example, states with relatively more vulnerability arguably need to make more extensive preparations to protect their residents.

   c. **Core public health preparedness.** Advisors argued that core elements of public health preparedness, which transcend specific threats, are essential ingredients for handling climate-related impacts.

2. **Academic literature review.** Researchers closely examined more than 200 articles (starting from a universe of 4,000). They identified the articles through three databases:

   - **PubMed.** Search terms included:
     a. "Climate Change"[Mesh] OR climate change*[tw] OR climate extreme*[tw] OR changing climate*[tw]
     b. "Public Health/methods"[Mesh Terms] OR "Risk Assessment/methods"[Mesh] OR "Risk/methods"[Mesh] OR readiness[tw] OR vulnerability[tw] OR vulnerable[tw] OR preparedness[tw] OR risk*[tw]
     c. "Health Status Indicators"[Mesh] OR indicators[tw] OR indices[tw]
     d. A and B and C

- **GeoBase.** Search terms included:
  a. ({Climate change} WN CV) OR ({climate effect} WN CV) OR ((climate change* OR climate extreme* OR changing climate*) WN KY)
  b. ({vulnerability} WN CV) OR ({assessment method} WN CV) OR ({risk assessment} WN CV) OR ((readiness OR vulnerability OR vulnerable OR preparedness OR adaptation OR risk*) WN KY)
  c. ({general biological phenomena} WN CV) OR ({life table} WN CV) OR ({environmental aspects and related phenomena} WN CV) OR ({environmental indicator} WN CV) OR ((indicators OR indices) WN KY)
  d. A and B and C

- **Scopus.** Search terms included:
  a. TITLE-ABS-KEY ("climate change*" OR "climate extreme*" OR "changing climate*")
  b. TITLE-ABS-KEY (readiness OR vulnerability OR vulnerable OR preparedness OR adaptation OR risk*)
  c. TITLE-ABS-KEY (indicators OR indices)
  d. TITLE-ABS-KEY("public health" OR disease* OR health OR asthma OR "food borne" OR "water borne" OR illness OR epidemiolog* OR morbidit* OR outbreak OR prevalence OR endemic OR incidence OR mortalit* OR "survival rate" OR "death rate" OR "fatality rate" OR "fatal outcome" OR "burden of disease" OR "disease burden" OR "years lived with disability" OR YLD* OR "Disability Adjusted Life Years" OR DALY* OR "years of life lost" OR YLL OR "health outcome*" OR population OR illness OR communities OR zoonotic OR "mental health")
  e. A and B and C and D

To be included, articles had to have a publication date within 10 years of the search and be available in English.

Once researchers identified an initial collection of articles, reviewers used Covidence to screen them for relevance, based on whether they included discussion or recommendations of (a) specific indicators or measures of state preparedness, or (b) adaptive actions. Researchers included the article if it met at least one of these criteria. Reviewers then coded the articles to address the following topics:

- Which of the following health impacts of climate change are directly addressed by the piece's indicators or adaptive actions? (Select all that apply.)
    - Extreme weather or weather-related events (extreme heat, drought, wildfires, extreme precipitation, flooding, hurricanes, sea-level rise, cold waves, and winter storms).
    - Outdoor air quality
    - Vector-borne infection
    - Water-related infection
    - Food-related infection
    - Mental health and well-being
    - Other (describe)
- Briefly list or describe the indicators and/or adaptive actions included in the piece.
- Briefly describe the underlying evidence and/or arguments for the indicators and/or adaptive actions included in the piece.
- For what time horizon (e.g., 2030, 2050, 2070) are the indicators and/or adaptive actions intended?
- How, if at all, do the indicators and/or adaptive actions address health equity (i.e., removal of economic and social obstacles to health)?
- Are the indicators or adaptive actions described as relevant or appropriate for:
    - A single state
    - A group of states or geographic region
    - All states
    - All states and territories
    - A mix (describe)
- If the piece includes indicators, what are their data sources and methods for collection of supporting data?
- If the piece includes adaptive actions, what is involved with implementation?
- Is there discussion of effective partnership, including through funding relationships, between states and federal, local, or peer state partners? Describe.
- Does the piece mention model states or localities? Describe.
- Are any studies or other materials referenced that should be included in the review?

Many of the included articles focused on the vulnerability of discrete places. Besides bolstering an understanding of those elements and how others have measured them, the prevalence of such articles reinforced that researchers needed to incorporate vulnerability into the set of indicators for this project.

3. **Grey literature review.** Researchers reviewed research completed by a number of leading organizations, including the USGCRP; the Council of State and Territorial Epidemiologists; *The Lancet*; the CDC; the U.S. National Academies of Sciences, Engineering, and Medicine; the World Health Organization; Climate Central & ICF International; the American Public Health Association; the Public Health Institute; and EcoAdapt. This research provided valuable insights that informed the scope and methodology of this project.

After gathering instructive information from these three sources, researchers conceptualized and shaped a coherent and comprehensive organizing framework built on three interrelated domains that would drive indicator selection:

- **Domain 1—Vulnerability.** This domain captures environmental factors (e.g., proximity to coastal flooding, frequency of extreme heat events), as well as social and demographic factors (e.g., poverty, race/ethnicity).

- **Domain 2—Public health preparedness.** This domain captures core elements of public health preparedness (e.g., surveillance, incident management, community engagement and coordination) that transcend individual threats. It measures readiness to prevent, prepare for, respond to, and recover from incidents that pose public health risks.

- **Domain 3—Climate-related adaptation.** This domain captures state preparations for understanding likely climate-related health impacts, assessing vulnerabilities and capacities, and planning for adaptive interventions.

Informed by this framework, researchers worked with a panel of advisors to identify and vet prospective indicators, data sources, and data-collection and analysis methods. The panel included the following advisors:

- John Balbus, M.D., MPH
  Senior Advisor, Public Health
  National Institute of Environmental Health Sciences (NIEHS)
  Director
  NIEHS-WHO Collaborating Centre for Environmental Health Sciences

- James S. Blumenstock
  Chief Program Officer, Health Security
  Association of State and Territorial Health Officials
- Anthony D. Moulton, Ph.D.

Senior Fellow
University of Minnesota School of Public Health

- Surili Sutaria Patel, M.S.
  Director, Center for Climate, Health and Equity
  American Public Health Association

- Linda Rudolph, M.D., MPH
  Senior Advisor
  Center for Climate Change and Health
  Public Health Institute

- Shubhayu Saha, Ph.D.
  Health Scientist
  Climate and Health Program
  National Center for Environmental Health
  Centers for Disease Control and Prevention

DATA COLLECTION AND CLEANING

Researchers collected raw data for every indicator. In some cases, data had to be normalized to make them comparable across states. After data were gathered, researchers who were uninvolved with the initial collection verified the accuracy of every data point. This was one of several quality-assurance steps taken.

Domain 1: Vulnerability

Domain 1 comprises two parts:

1. **environmental factors:** aspects of place that make consequential physical environmental change more likely or severe; and

2. **social and demographic factors:** population characteristics that—owing to a variety of circumstances, including the legacy and continuation of structural and systemic racism—influence vulnerability.

Environmental factors

Measuring environmental factors requires a set of indicators that represent different types of geography and extreme weather events. Existing measures include indicators of harm, as well as indicators of vulnerability to harm (e.g., numbers of events vs. proximity to a hazard or potential exposure).

The measures of environmental vulnerability used in this analysis include (see Table A.1):

- **Extreme heat (D1.1): Number of days per year with a maximum temperature above the 95th percentile for the area**

  Researchers calculated county-level data from the CDC's National Environmental Public Health Tracking Network for 2014 to 2016, the most recent years available. For each year, researchers averaged the number of days of extreme heat in counties to calculate an annual statewide mean. Then, they averaged each state's three annual means to calculate a three-year statewide mean. They included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

- **Flooding (D1.2): Percent of state population living within a Special Flood Hazard Area (SFHA)**

  Researchers collected data from the CDC's National Environmental Public Health Tracking Network, which provides estimates of the number of people residing within the SFHA, based on FEMA's 2011 National Flood Hazard Layer, a conservative measure. SFHAs have a 1 percent annual chance of coastal or riverine flooding. Researchers normalized data by dividing the number of people living within an SFHA by that state's 2010 population, according to the U.S. Census Bureau, producing an approximate percentage of people in each state living in an SFHA.

- **Drought (D1.3): Number of days with a drought event**

  Researchers collected data for this indicator from NOAA's Storm Events Database. This measures the number of days with drought conditions over a three-year period (November 1, 2016, to October 31, 2019). Researchers included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

  The Storm Events Database registers a drought event based on the drought classification system, which is the foundation of the Drought Monitor, a multiagency effort. Droughts begin when an area reaches Severe (D2) or Extreme (D3) classification, or when drought begins to cause significant impact to people, animals, or vegetation. Droughts end when an area is no longer in at least Severe (D2) or Extreme (D3) classification, or when drought no longer causes significant impacts.

- **Wildfire (D1.4): Percentage of zones in a state affected by "significant wildfire"**

  Researchers collected data for this indicator from NOAA's Storm Events Database. The indicator measures the number of zones in a state with any significant forest fire, grassland fire, rangeland fire, or wildland-urban interface fire that consumed natural fuels and spread in response to its environment over a three-year period (November 1, 2016, to October 31, 2019). NOAA defines "significant" as a wildfire that directly causes one or more fatalities, one or more significant injuries, and/or property damage. In general, it does not include forest fires smaller than 100 acres, grassland or rangeland fires smaller than 300 acres, and wildland use fires not actively managed as wildfires. Researchers included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

  Researchers divided the number of zones affected by the number of zones in a state to derive a percentage for each state.

- **Severe storms (D1.5): Number of days with a severe storm causing injury and/or death**

  Researchers collected data for this indicator from NOAA's Storm Events Database. This indicator represents the number of days with severe storms causing injury and/or death over a three-year period (November 1, 2016, to October 31, 2019). Types of severe storms included in the indicator were those with thunderstorm winds, tornados, tropical depressions, tropical storms, and hurricanes. Researchers included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

- **Vector-borne infectious disease (D1.6): Presence of vectors for Lyme disease, Powassan virus, chikungunya virus, and West Nile virus**

  This indicator considers the presence or absence of exemplar disease vectors of concern in order to assess future risk. Using NASA's mosquito distribution map and the CDC's estimates of the range of *Aedes aegypti* and various tick species, the indicator assesses the likely presence of exemplar mosquitoes (*Culex pipiens* and *Aedes aegypti*) and blacklegged ticks (*Ixodes scapularis* or *Ixodes pacificus*).[332,333,334]

  Researchers quantified presence by assessing 1 point for each vector if any part of a state appeared to be within the boundaries of that vector's range, and 0 points for each vector if no part of the state appeared to be within its range. Then researchers added the points, producing a scale of 0 to 3, with 3 points reflecting the presence of every vector and 0 points reflecting the presence of no disease vectors.

Table A.1
Measures of Environmental Vulnerability

INDICATOR	MEASURE	SOURCE
D1.1 Extreme heat	Number of days per year with a maximum temperature above the 95th percentile for the area, 2014–2016	CDC National Environmental Public Health Tracking Network
D1.2 Flooding	Percent of the population residing within FEMA-designated Special Flood Hazard Areas	CDC National Environmental Public Health Tracking Network
D1.3 Drought	Number of days with a drought event (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.4 Wildfire	Percent of zones with significant wildfire (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.5 Severe storms	Number of days with a severe storm causing injury or death (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.6 Disease vectors	Likely presence of each of three exemplar vectors, varied timeframes	NASA; CDC National Center for Emerging and Zoonotic Infectious Diseases, Division of Vector-Borne Diseases

Social and demographic factors

Following a review of existing resilience and vulnerability indexes, the CDC's Social Vulnerability Index heavily informed the social and demographic measures in this analysis. They span four key areas: (1) socioeconomic status, (2) household composition and disability, (3) housing and transportation, and (4) minority status and language. Researchers collected all data from the U.S. Census Bureau's 2018 American Community Survey. (See Table A.2.)

Table A.2

Measures of Social and Demographic Vulnerability

INDICATOR	MEASURE	SOURCE
D1.7 Poverty	Percentage of people living in poverty, 2018	U.S. Census Bureau 2018 American Community Survey
D1.8 Income inequality	Gini coefficient, 2018	
D1.9 Age composition	Percentage of population under age 5 or over age 64, 2018	
D1.10 Race/ethnicity composition	Percentage of population that was nonwhite, 2018	
D1.11 Disability	Percentage of population with a disability, 2018	
D1.12 Housing	Percentage of population living in mobile homes, 2018	
D1.13 Transportation	Percentage of population without a motor vehicle, 2018	
D1.14 Language proficiency	Percentage of households with member(s) who speak limited English, 2018	
D1.15 Education level	Percentage of population age 25 or older without a bachelor's degree, 2018	

Notes: The **Gini coefficient** summarizes dispersion of income, ranging from 0 (perfect equality) to 1 (perfect inequality). All social and demographic indicators relied on one-year estimates of the U.S. Census Bureau's 2018 American Community Survey (ACS). The ACS, like any other sample survey, is subject to error. Each indicator was based on the ACS's subject definitions.

Quality assurance
Once data supporting each indicator were collected by one researcher, a second researcher double-checked each data point to confirm its accuracy.

Limitations
This assessment measures statewide vulnerability. Thus, it draws on measures that are available and meaningful at the state level. These measures do not capture all facets of vulnerability. Researchers excluded many individual risk factors, such as those related to occupation or lifestyle. The assessment does not take into account the built environment and other neighborhood-level characteristics, nor does it consider differences in culture or governance that could mitigate or exacerbate vulnerabilities.[335] Indicators tracked within Domain 2 explore some of these attributes through the lens of public health preparedness, but the landscape of relevant policies, programs, and social institutions extends further.

The measures captured here provide valuable information about states, but a fuller understanding requires also tracking them at a smaller geographic scale, such as by county or census tract. Just as there is variation across states, there is also significant variation within states that is obscured by the absence of more granular data.

Data on extreme heat (D1.1) were not available for Alaska or Hawaii; their scores do not capture that element of exposure. This is unfortunate, given that the western half of the country, including Alaska, has experienced the country's largest increases in annual temperature since 1901, and Alaska in particular has experienced sharp increases in recent decades.

Data on flooding (D1.2) were calculated using FEMA-designated Special Flood Hazard Areas, a source widely considered to use conservative and, in some cases, outdated estimates. For example, a June 2020 report identified nearly 70 percent more homes at substantial risk of flooding than are within SFHAs.[336,337]

Domain 2: Public health preparedness

The National Health Security Preparedness Index (NHSPI), a joint initiative of the Robert Wood Johnson Foundation, the University of Kentucky, and the University of Colorado, organizes its indicators across six domains: (1) health security surveillance, (2) community planning and engagement coordination, (3) incident and information management, (4) healthcare delivery, (5) countermeasure management, and (6) environmental occupational health. The NHSPI breaks out each domain into subdomains, ultimately encompassing 129 measures in its 2019 edition, the one used for this project.

To home in on segments of the index most pertinent to preparations for the health effects of climate change, while also retaining an expansive view, researchers for this project worked closely with those who manage NHSPI to select a targeted set of 11 subdomains (out of 19). Each subdomain contains multiple measures. (See Table A.3.) "Appendix B: Domain 2 Underlying Indicators" provides a list of measures tracked within each NHSPI subdomain.

Table A.3

Climate-Related NHSPI Subdomains Measuring Public Health Preparedness

DOMAIN	SELECTED SUBDOMAIN(S)	DESCRIPTION
Health security surveillance	D2.1 Health surveillance and epidemiological investigation	The development and maintenance of systems and processes that enable detection, identification, and tracking of health threats, including disease outbreaks and adverse events.
Community planning and engagement coordination	D2.2 Cross-sector / community collaboration	The coordination necessary to engage community-based organizations and social networks through collaboration among state agencies and their partners in order to return to routine delivery of services effectively and efficiently.
	D2.3 Social capital and cohesion	The degree of connection and sense of belonging among residents, including social networks among individuals, neighbors, organizations, and governments.
Incident and information management	D2.4 Incident management	The ability to establish and maintain a unified and coordinated operational structure that appropriately integrates all stakeholders and supports the execution of core capabilities and incident objectives through information sharing, strategy development, and resource management.
	D2.5 Information management	The ability to develop systems and procedures that communicate timely, accurate, accessible, and appropriate information and alerts to the public using a whole-community approach.

Healthcare delivery	D2.6 Prehospital care	Care provided by emergency medical services (EMS), including 911 and dispatch, emergency medical response, field assessment and care, and transport to a hospital or between healthcare facilities.
	D2.7 Hospital and physician services	Care for patients who are formally admitted to a hospital or other institution for inpatient treatment.
	D2.8 Long-term care	A continuum of medical and social services, including skilled nursing and rehabilitation, designed to support the needs of people living in residential-care settings with chronic health problems that affect their ability to perform everyday activities.
	D2.9 Behavioral healthcare	The provision and facilitation of access to behavioral health services, including medical treatment, substance-abuse treatment, stress management, medication, and social-services networks.
	D2.10 Home care	Clinical and nonclinical care that allows a person with special needs to stay in their home, including skilled nursing visits, respiratory-care services, provision of durable medical equipment, hospice, and pharmacist services.
Environmental and occupational health	D2.11 Environmental monitoring	The systematic collection and measurement of environmental specimens (air, water, land/soil, and plants) to analyze the presence of an indicator, exposure, or response (warning and control). This includes monitoring the environment for disease vectors.

Note: Researchers adapted domain descriptions with light edits from NHSPI. See "Appendix B: Domain 2 Underlying Indicators" for a list of indicators tracked within each subdomain.

Source: National Health Security Preparedness Index[338]

NHSPI researchers use a normalization method to convert each measure to a standardized scale (0–1) before combining measures into subdomain, domain, and overall composite measures of preparedness. This improves the validity and reliability of composite measures. NHSPI then aggregates individual measures for each state using a weighted arithmetic mean. The index bases the weighting on a multistage Delphi process in which experts judged the relative importance of each measure, subdomain, and domain. Finally, NHSPI multiplies each measure by 10 to place it on a 10-point scale, with 10 being the highest possible level of preparedness.

Researchers for this project incorporated NHSPI's data by collecting aggregated subdomain scores for each of the 11 subdomains selected and for every state and the District of Columbia.

Quality assurance

Once one researcher collected NHSPI's aggregated subdomain scores, a second researcher double-checked each data point to confirm its accuracy.

Limitations

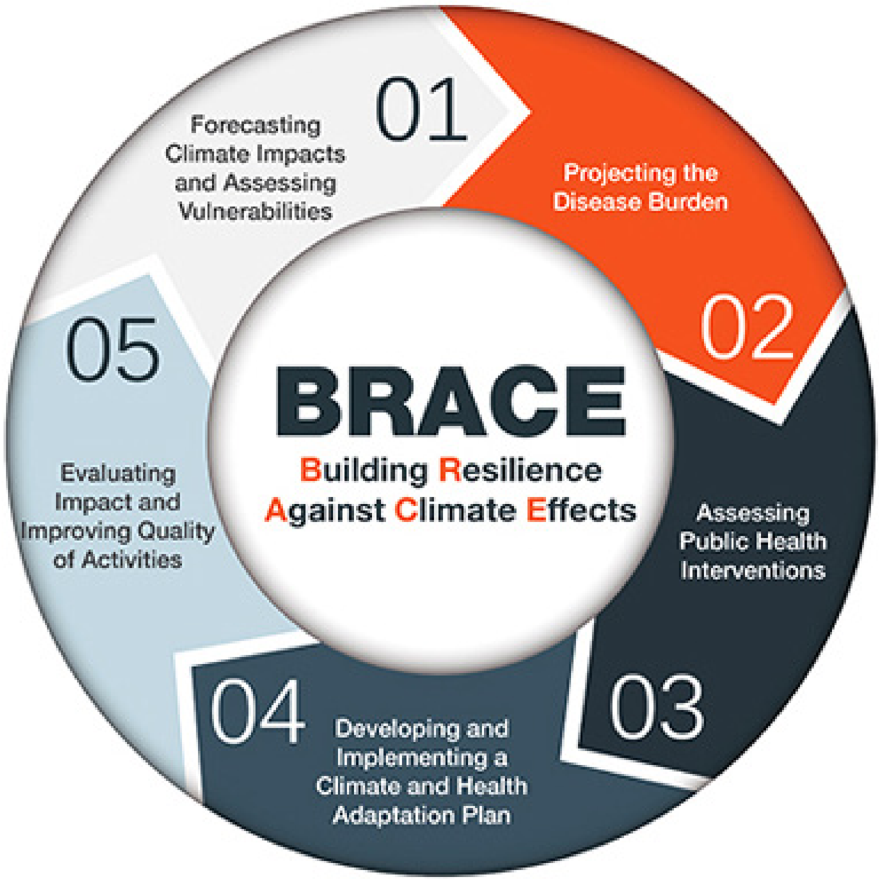
NHSPI is transparent that each indicator comprising the index has its own limitations.[339] The index overall is considered highly credible, drawing on input from experts as well as a broad range of stakeholders. NHSPI rigorously vets indicators, and each iteration of the index refines these measures further. Of greater uncertainty is whether the subset of measures chosen for this assessment provides an accurate picture of state preparedness for climate-related health threats. Researchers drew on expert resources and worked closely with NHSPI staff to identify the subdomains that best reflect the core public health capabilities required to address climate change impacts. However, researchers have not validated this collection of measures against data on state performance in responding to actual climate-related health emergencies.

Unlike NHSPI, which released its sixth annual index in 2019, this assessment does not provide information about trends over time. The 2019 index suggested that, overall, the country's performance is improving, but there are important differences between states and regions. While almost two-thirds of states saw an improvement in health security in 2018, four states saw a decline, and 14 held steady.[340] Given the expectation of worsening threats owed to climate change and other trends, improvements in health security are needed just to keep pace. Thus, it is important to understand how the relevant core public health capabilities are changing over time.

Domain 3: Climate-related adaptation

Following the initial literature review and planning process, researchers developed a set of indicators and sub-indicators based on the CDC's BRACE framework. The framework is an iterative five-step cycle for health officials to identify the likely effects of climate change on local communities and their health and to incorporate this information into preparedness and adaptation planning.[341] (See Figure A.1.) Through its Climate-Ready States and Cities Initiative, the CDC had supported implementation of the BRACE framework in 16 states and two cities, as of October 2020. The agency has also developed publicly available resources to guide other jurisdictions in conducting this work.

Figure A.1
The CDC's Building Resilience Against Climate Effects (BRACE) Framework



Source: Centers for Disease Control and Prevention[342]

Drawing primarily on the first and third steps of the framework, researchers developed two main indicators to measure each state's progress in assessing its vulnerabilities and identifying evidence-based adaptive interventions. The assessment was based on a systematic review of relevant state documents. Researchers developed a coding rubric, breaking down each indicator into a set of criteria represented by yes/no questions. (See Table A.4.)

Table A.4
Domain 3 Indicator Coding Rubric

INDICATOR	SUB-INDICATORS	CODE 0	CODE 1
D3.1: Has the state assessed its vulnerability to the public health impacts of climate change?	D3.1.1: Have climate-related exposures (e.g., elevated temperatures, contaminated water, worsened air quality) to the state been identified?	No identification of climate-related exposures.	Identified climate-related exposures.
	D3.1.2: Have climate-sensitive health outcomes (e.g., heat-related death and illness, gastrointestinal illness, premature death) been identified?	No identification of climate-sensitive health outcomes.	Identified climate-sensitive health outcomes.
	D3.1.3: Have risk factors for health outcomes been identified?	No identification of risk factors.	Identified risk factors for specific climate-related health outcomes.
	D3.1.4: Have causal pathways been developed for relevant climate-related hazards?	No causal pathway(s) developed.	Developed causal pathway(s) linking climate-sensitive exposures to health outcomes. Pathways generally had to involve at least three parts: (1) changes in climate --> (2) manifestations of weather/ exposure --> (3) health impact.
	D3.1.5: Have climate projections at the state or state and local scale been reported?	No climate projections reported.	Reported climate projections framed in the context of the state.
	D3.1.6: Have the most vulnerable populations in the state been identified (D3.1.6.1)? If so, have they been located (D3.1.6.2)?		
	D3.1.6.1: Have the most vulnerable populations in the state been identified?	No identification of the most vulnerable populations.	Identified the most vulnerable populations based on social or demographic factors. OR Identified the most vulnerable populations based on environmental factors. *Either relevant excerpt(s) in state documents or the entire document must have had a health and/or climate change orientation.*
	D3.1.6.2: Have the most vulnerable populations in the state been located? *Location must have been precisely defined (e.g., census tract, county, climate zones, neighborhoods). Maps were not required.*	No identification of the most vulnerable populations. AND/OR No location of the most vulnerable populations.	Locates vulnerable populations based on social or demographic factors. OR Locates vulnerable populations based on environmental factors. *Either relevant excerpt(s) in state documents or the entire document must have had a health and/or climate change orientation.* OR Discusses urban heat islands and/ or other aspects differentiating urban and rural locations in the state. *Urban/rural locations did not need to be precisely defined.*

INDICATOR	SUB-INDICATORS	CODE 0	CODE 1
D3.2: Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?	D3.2.1: Has the state identified interventions?	No interventions identified.	Identified interventions.
	D3.2.2: If interventions have been identified, are they evidence-based? *To qualify as "evidence-based," an intervention must have been supported by citing: (1) evidence that the intervention has been implemented and effective within the state's borders, (2) evidence that the intervention has been implemented and effective in another state, or (3) credible third-party evidence that the intervention would be effective for the identified risk.* *The intervention was also considered to be evidence-based if it was classified in a relevant CDC BRACE guidance document as: (1) scientifically supported, (2) having some evidence, or (3) supported by expert opinion.*[343]	No interventions identified. AND/OR Interventions not evidenced-based.	Qualifying evidence was cited and/or the interventions were identified as evidence-based by the CDC guidance document.

A group of data collectors were trained on the Domain 3 assessment approach and provided with a written protocol to guide data collection. Each data collector was assigned a set of states at random and asked to identify and review relevant documents, and then code state data using the rubric.

Document identification

To answer the questions posed by the indicators and sub-indicators, researchers reviewed and collected relevant qualitative data from state documents related to climate change and health. Because the goal was measuring state preparedness, documents had to have a state-level focus and be produced by the state government or on its behalf (e.g., assessments from an academic institution that were commissioned by a state agency). But no other restrictions were placed on the type of document; any document that addressed climate change or its impact on human health was considered relevant, as was content on relevant web pages. Some states had produced formal climate adaptation plans or climate action plans, but documents did not have to meet this standard for inclusion.

Data collectors began by reviewing each state's most recent hazard-mitigation plan. FEMA requires states to develop and submit these plans in order to receive certain funding, and the plans must address "changing environmental or climate conditions" in their risk assessment.[344] Thus, each state has a hazard-mitigation plan that can serve as a baseline source for climate change planning. To locate the document, data collectors conducted a basic Google search using the state's name and the keywords

"state hazard mitigation plan." To ensure that they located the current plan, data collectors checked the most recent year of publication, according to a September 2019 report by the Columbia Law School Sabin Center for Climate Change Law.[345] In some cases, data collectors identified a hazard-mitigation plan published more recently than the year listed by Columbia. They used the most recent document for review. In addition to identifying and reviewing documents, data collectors archived the relevant files in a standardized format.

To identify additional documents, data collectors first looked to four existing repositories of state-level adaptation resources:

1) Georgetown Climate Center's Adaptation Clearinghouse[346]
2) Center for Climate and Energy Solutions' (C2ES) U.S. State Climate Action Plans database[347]
3) EcoAdapt's 2019 report *The State of Climate Adaptation in Public Health: An Assessment of 16 U.S. States*[348]
4) CDC's Climate-Ready States & Cities Initiative grantee website[349]

Data collectors checked each resource and reviewed the materials listed for each state to determine which, if any, were relevant to the scope of this assessment. They determined relevance through a quick keyword search for certain terms: "climate change," "climate," and "health." Once reviewed, they archived both relevant and non-relevant documents, using a naming convention that tracked the document's source.

Data collectors identified additional documents through an advanced Google search using the term: "[state name] climate change adaptation." Data collectors first identified the appropriate state government web domain or sub-domain. They used this domain to restrict the search results through Google's Advanced Search function. They determined document relevance using the keyword method described above. Once they identified relevant documents, data collectors archived the document file in a standardized format.

Document evaluation and coding

Data collectors used the table of contents and keyword searches ("climate change," "climate," and "health") to identify relevant sections in source documents. They highlighted these sections of text in archived PDF files to facilitate later review. Data collectors looked for information relevant to each sub-indicator. If they found such information, they excerpted relevant sections of text and pasted them into an Excel spreadsheet table, along with the source and page numbers. Data collectors did not intend the excerpts to be comprehensive. Depending on the extent of the information presented in a document, the collected excerpts might represent only a small sample of the relevant text. For each sub-indicator, data collectors provided a brief, one-sentence summary describing the relevant information in that source; they intended this summary to provide a rationale for the coding. On average, researchers collected data from four documents per state; they may have reviewed additional documents.

Researchers ultimately coded each sub-indicator dichotomously as 0 or 1, after first exploring a 0–1–2 coding system, with 2 representing deeper-level information. Researchers coded most sub-indicators independently, but there were two exceptions in which one sub-indicator was contingent on another: vulnerable populations cannot be located (D3.1.6.2) without first being identified (D3.1.6.1), and an intervention must be identified (D3.2.1) to be considered evidence-based (D3.2.2).

To limit subjectivity and maintain consistency across data collectors, researchers premised scoring on the presence of relevant information, rather than an evaluation of the quality or depth of content. Beyond determining whether data reasonably addressed the question, researchers did not consider the veracity, completeness, or depth of the data.

Data verification and reconciliation

Once data had been collected for every state, researchers transferred each state's data to a separate Excel file and provided it, along with instructions and background information on the project, to the state government for review and verification. Typically, this information went to the highest-ranking public health and emergency management officials. The verification file contained three worksheets: one sheet with instructions and a copy of the data that had been collected, and two sheets with blank tables for the state to provide additional documents or excerpts that were relevant. In response, 29 states confirmed the veracity and completeness of the data or provided additional materials for possible inclusion.

As states responded, a single data collector reviewed the information and filled in gaps as new information allowed. Because of the dichotomous coding system, based on presence rather than depth or breadth, researchers did not review all submitted documents. During this reconciliation process, researchers reviewed data compiled for each state again to ensure accurate and consistent coding. They revised coding, as necessary, based on newly submitted information or to correct for previous inconsistencies.

Quality assurance

Once researchers completed coding, they developed a quality-assurance protocol implemented by two researchers—one who had been involved in the data-collection and review process, and one who had not. Independently, the two researchers went through each state's Excel verification file to ensure that codes had been assigned appropriately—that is, a code of 1 was assigned when data were provided in the relevant cell(s) and a code of 0 was assigned when no data were provided. For each sub-indicator that received a code of 0, researchers reviewed the original verification file to ensure that no relevant information had been lost during the state response process or subsequent reconciliation. Researchers also confirmed that the appropriate source document was excerpted and cited (i.e., the cell did not merely contain a reference to work done elsewhere), and that all source documents were listed on the verification file. Finally, researchers checked the response provided by the state (if any) to ensure that all relevant resources and data had been collected and were reflected in the final coding.

Limitations

While the CDC's BRACE framework inspired the Domain 3 indicators, researchers did not measure states against the standard of an extensive application of it. Scoring states based on the presence or absence of relevant data obscures in some cases meaningful differences between states that had taken tentative early steps and those that had made more substantive progress toward adapting to new climate conditions. For example, one state might have included a passing reference to climate change in its hazard-mitigation plan, noting that the state expects to experience an increase in temperature and a change in precipitation patterns over the next few decades, and that heat-related illnesses could increase, along with a loss of life related to flooding or severe storms. In contrast, another state might have included a detailed analysis of climate trends and potential impacts related to each hazard in its mitigation plan and produced documents on the likely health impacts of multiple climate-related exposures. Although the latter state demonstrated a deeper level of planning for specific local climate changes, the two states might receive the same score in this analysis. A perfect score does not necessarily indicate that a state has fully prepared for the health impacts of climate change, but rather that it has laid a foundation for doing so by identifying at least some of its vulnerabilities and potential interventions.

Importantly, this assessment does not address implementation. The data gathered come from state-level discussions and plans; the study does not consider whether these plans have been funded or carried out. States can appear on par with one another when assessed based on planning documents but differ significantly in actual performance. This limitation is particularly salient for Indicator 2, which addresses the identification of evidence-based interventions. Furthermore, because adaptation seeks to address and minimize specific risks, important interventions often take place at the local level. A number of states highlighted county- or city-level initiatives in their documents—not factored into scores for this analysis—but state-level assessments do not always capture the full extent of work done by localities.

During the initial review process, data collectors searched using the terms, "climate," "climate change," and "health." These terms did not always return relevant sections of documents. States may be preparing for likely impacts of climate change without defining preparedness and adaptation efforts as such. This may reflect political considerations or the division of roles and responsibilities among state agencies. Furthermore, the absence of publicly available documents does not necessarily indicate that a state is not analyzing or preparing for the public health impacts of climate change. In some cases, researchers identified or were provided with presentations and other resources that hint at a larger body of relevant work. The low profile may represent the early stages of a state's response, an intentional decision to conduct this work under the auspices of existing health and emergency management programs, or a decision to not post their work publicly.

Finally, the data-verification process, during which researchers provided state leaders with collected data and invited them to review them for completeness and accuracy, was intended to give states an opportunity to correct oversights or misunderstandings, and 29 states responded. However, given the timing—as the COVID-19 pandemic began to sweep across the country in early 2020—some health departments may not have been able to devote as much attention to their responses as they would have under usual circumstances. Others did not respond at all, leaving open the possibility that relevant data were inadvertently left out of this analysis.

SCALING AND SCORING INDICATORS ACROSS DOMAINS

Once the normalized data set for all indicators was complete, researchers scored states at the sub-sub-indicator, sub-indicator, indicator, subdomain, domain, and grouped domain (Vulnerability: Domain 1; Preparedness: Domains 2 & 3) levels.

To score indicators, researchers first transformed disparate state data. They did this for every indicator except for those within Domain 2, as the data collected from NHSPI had already been transformed using a similar process. Transformation was applied using a multistep process:

1. Researchers first applied the Box-Cox transformation, a parameterized power transformation, to normalize the distribution of states' data.
2. To make indicator scores comparable across states, researchers then applied z-score transformation, an expression of the number of standard deviations by which a data value is above or below the mean for a given indicator. State scores, for every indicator, were then centered at a z-score of 0 (i.e., the state mean) and at the same level of variability, making data for different indicators comparable and allowing researchers to average scores for multiple indicators to calculate aggregate values.
3. To reduce the influence of outliers, z-score values were truncated for each indicator at 3.5 standard deviations above or below the state means. That is, state data that diverged by more than 3.5 standard deviations were converted to a z-score of 3.5.
4. Finally, researchers applied a min-max scale to place state scores for every indicator within a range of 0–10.

After completing the transformation process, researchers were able to aggregate state scores for discrete indicators into summary measures across subdomains, domains, and grouped domains. They combined measures into simple unweighted averages, ignoring missing values. Aggregate calculations included:

- **Domain 1. Vulnerability**—unweighted average of scores for two subdomains: environmental factors and social and demographic factors.
    - **Subdomain: environmental factors**—unweighted average of scores for indicators D1.1 through D1.6.
    - **Subdomain: social and demographic factors**—unweighted average of scores for indicators from D1.7 to D1.15.
- **Domain 2. Public health preparedness**—unweighted average of scores for indicators D2.1 through D2.11.
- **Domain 3: Climate-related adaptation**—unweighted average of scores for indicators D3.1 and D3.2.
    - **Indicator D3.1: vulnerability assessment**—unweighted average of sub-indicators D3.1.1 through D3.1.6. The score for sub-indicator D3.1.6 reflects an unweighted average of sub-sub-indicators D3.1.6.1 and D3.1.6.2.
    - **Indicator D3.2: intervention identification**—unweighted average of sub-indicators D3.2.1 and D3.2.2.
- **Grouped domain: Vulnerability**—score for Domain 1.
- **Grouped domain: Preparedness**—unweighted average of scores for Domain 2 and Domain 3.

APPENDIX B: DOMAIN 2 UNDERLYING INDICATORS

Table B.1
Indicators Supporting Selected NHSPI Subdomains

NHSPI Subdomain	Indicator	Year Tracked	Source
Health surveillance and epidemiological investigation	State health department participates in the Behavioral Risk Factor Surveillance System (BRFSS)	2015	CDC, BRFSS, survey data analyzed by authors
	Number of epidemiologists per 100,000 population in the state, by quintile	2017	Bureau of Labor Statistics (BLS), Occupational Employment Statistics (OES), and ASTHO Profile of State and Territorial Public Health—2012 and 2016 Epidemiologists by Jurisdiction
	State health department participates in the Epidemic Information Exchange (Epi-X) System	2013	CDC Epi-X Program
	State health department participates in the National Electronic Disease Surveillance System (NEDSS)	2015	CDC Division of Health Informatics and Surveillance (DHIS), NEDSS
	State health department has an electronic syndromic surveillance system that can report and exchange information	2016	ASTHO Profile of State Public Health: Volume Three
	State public health laboratory has implemented the laboratory information management system to exchange laboratory information and results electronically with hospitals, clinical labs, state epidemiology units, and federal agencies	2016	Association of Public Health Laboratories (APHL), Comprehensive Laboratory Services Survey (CLSS)
	State has legal requirement for nongovernmental laboratories (e.g., clinical, hospital-based) in the state to send clinical isolates or specimens associated with reportable foodborne diseases to the state public health laboratory	2016	APHL, CLSS
	State public health laboratory participates in either of the following federal surveillance programs: Foodborne Diseases Active Surveillance Network or National Molecular Subtyping Network for Foodborne Disease Surveillance	2014	APHL, CLSS
	Percent of foodborne illness outbreaks reported to the CDC by state and local public health departments for which a causative infectious agent is confirmed	2017	CDC National Outbreak Reporting System (NORS)
	State health department participates in a broad prevention collaborative addressing healthcare-associated infections	2013	CDC National Healthcare Safety Network (NHSN), Prevention Status Reports
	State has a public health veterinarian	2019	National Association of State Public Health Veterinarians, Designated and Acting State Public Health Veterinarians
	State uses an Electronic Death Registration System	2018	National Association for Public Health Statistics and Information Systems, Electronic Death Registration Systems by Jurisdiction (State)
	State public health laboratory participates in the CDC influenza surveillance program, and/or the World Health Organization Influenza Surveillance Network	2014	APHL, CLSS

NHSPI Subdomain	Indicator	Year Tracked	Source
Cross-sector/ community collaboration	State health department is accredited by the Public Health Accreditation Board (PHAB)	2018	PHAB, Health Departments in e-PHAB
	Percent of the state's population served by a comprehensive public health system, as determined through the National Longitudinal Survey of Public Health Systems	2016	National Longitudinal Survey of Public Health Systems, National Association of County and City Health Officials (NACCHO), and Area Resource File data analyzed by project management office (PMO) and affiliated personnel
	Percent of hospitals in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of the Office of the Assistant Secretary for Preparedness and Response (ASPR)	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
	Percent of emergency medical service agencies in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of ASPR	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
	Percent of emergency management agencies in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of ASPR	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
	Percent of local health departments in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of ASPR	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
Social capital and cohesion	Percent of voting-eligible population in the state participating in the highest office election	2016	United States Election Project, General Election Turnout Rates
	Percent of adults in the state who volunteer in their communities	2017	Current Population Survey (CPS), Volunteer Supplement data analyzed by PMO personnel
	Number of annual volunteer hours per state resident, 15 years or older	2017	CPS, Volunteer Supplement data analyzed by PMO personnel

Incident management	State public health laboratory uses a rapid method (e.g., Health Alert Network, blast e-mail, or fax) to send messages to their sentinel clinical laboratories and other partners	2016	APHL, All-Hazards Laboratory Preparedness Survey
	State all-hazards emergency management program is accredited by the Emergency Management Accreditation Program (EMAP)	2018	EMAP
	Percent of local health departments in the state with an emergency preparedness coordinator for states with local health departments, excludes Rhode Island and Hawaii	2016	NACCHO, 2013 National Profile of Local Health Departments
	State public health laboratory has a 24/7/365 contact system in place to use in case of an emergency	2014	APHL, CLSS
	State uses a system for tracking hospital-bed availability during emergencies	2018	ASPR Hospital Preparedness Program
	Average number of minutes for state health department staff with incident management lead roles to report for immediate emergency response duty	2016	CDC Office of Public Health Preparedness and Response, National Snapshot of Public Health Preparedness
	State has adopted the Nurse Licensure Compact (NLC)	2018	National Council of State Boards of Nursing (NCSBN), NLC Member States
	State requires healthcare facilities to report healthcare-associated infections to the CDC's National Health Safety Network (NHSN) or other systems	2013	CDC, NHSN Healthcare–Associated Infections Progress Report
	State law includes a general provision regulating the release of personally identifiable information held by the health department	2013	CDC Public Health Law Program resources (https://www.cdc.gov/phlp/)
	State law requires healthcare facilities to report communicable diseases to a health department	2013	CDC, DHIS, NEDSS
	State has adopted Emergency Management Assistance Compact legislation	2014	National Emergency Management Association

Information management	State has a public-information and communication plan developed for a mass prophylaxis campaign	2018	CDC Public Health Emergency Preparedness and Response Cooperative Agreement Program
	Percent of households in the state with broadband in the home	2017	U.S. Census Bureau American Community Survey (ACS), one-year estimate
	Percent of hospitals in the state that have demonstrated meaningful use of certified electronic health record technology; this includes the demonstration of meaningful use through either the Medicare or Medicaid EHR Incentive Programs. Critical Access hospitals are facilities with no more than 25 beds and located in a rural area farther than 35 miles from the nearest hospital, and/or are located in a mountainous region.	2016	The Office of the National Coordinator for Health Information Technology, a division of the U.S. Department of Health and Human Services
	The state's 911 authorities are capable of processing and interpreting location and caller information using Next Generation 911 infrastructure	2017	National 911 Program, Office of Emergency Medical Services, National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation
	Number of emergency medical technicians and paramedics per 100,000 population in the state	2017	BLS, OES
Prehospital care	Percent of local emergency medical services (EMS) agencies that submit National EMS Information System (NEMSIS) compliant data (e.g., Version 2 in earlier years, Version 3 in later years) to the state	2019	NHTSA, State NEMSIS Progress Reports: State & Territory Version 2 Information
	State has adopted EMS Personnel Licensure Interstate CompAct legislation	2018	National Association of State EMS Officials
	The average length of time in minutes between EMS notification and arrival at a fatal motor vehicle crash (MVC) in urban areas	2017	NHTSA, Fatality Analysis and Reporting System (FARS)
	The average length of time in minutes between EMS notification and arrival at a fatal MVC in rural areas	2017	NHTSA, FARS
	Median time in minutes from hospital emergency department (ED) arrival to ED departure for patients admitted to hospitals in the state (identifier ED-1)	2018	Centers for Medicare and Medicaid Services (CMS), Timely and Effective Care—State

Hospital and physician services	Median time in minutes from hospital admission decision to ED departure for patients admitted to hospitals in the state (identifier ED-2)	2018	CMS, Timely and Effective Care—State
	Percent of the state's population who live within 50 miles of a trauma center, including out-of-state centers	2017	American Hospital Association (AHA) Annual Survey of Hospitals data and U.S. Census
	Number of physicians and surgeons per 100,000 population in the state	2017	U.S. Census ACS
	Number of active registered nurse and licensed practical nurse licenses per 100,000 population in the state	2019	NCSBN, National Nursing Database
	Percent of the state's population living within 100 miles of a burn center, including out-of-state centers	2018	American Burn Association data on Burn Care Facilities analyzed by PMO personnel
	Percent of hospitals in the state providing a specialty geriatric-services program (includes general as well as specialized geriatric services, such as psychiatric geriatric services/ Alzheimer care)	2017	AHA Annual Survey of Hospitals
	Percent of hospitals in the state providing palliative-care programs (includes both palliative-care program and/or palliative-care inpatient unit, but excludes pain-management program, patient-controlled analgesia, and hospice program)	2017	AHA Annual Survey of Hospitals
	Number of hospital airborne infection isolation room (AIIR) beds per 100,000 population in the state, including hospitals with AIIR rooms within 50 miles from neighboring states	2017	AHA Annual Survey of Hospitals
	Risk-adjusted 30-day survival rate (percent) among Medicare beneficiaries hospitalized in the state for heart attack, heart failure, or pneumonia	2016	The Commonwealth Fund, Aiming Higher: Results from a Scorecard on State Health System Performance
	Percent of hospitals in the state with a top-quality ranking (Grade A) on the Hospital Safety Score	2018	The Leapfrog Group, Hospital Safety Score
	Average number of nurse staffing hours per resident per day in nursing homes in the state	2018	CMS Nursing Home State Averages

Long-term care	Average number of nursing assistants (staffing hours per resident per day) in nursing homes in the state	2018	CMS Nursing Home State Averages
	Percent of long-stay nursing-home residents in the state who are assessed and appropriately given the seasonal influenza vaccine	2018	CMS Nursing Home State Averages
	Average number of licensed practical nurse staffing hours per resident per day in nursing homes in the state	2018	CMS Nursing Home State Averages
	Number of licensed skilled nursing facilities with deficiencies in compliance with CMS Emergency Preparedness requirements, per 100 facilities in the state (expressed as quintiles)	2018	CMS Nursing Facility Inspection Reports
	Number of disease outbreaks in nursing homes or assisted-living facilities per 1,000 certified nursing-home residents in a state	2017	CDC, NORS
	Percent of hospitals in the state providing psychiatric emergency services	2017	AHA Annual Survey of Hospitals
Behavioral health care	Percent of need met for mental healthcare in health professional shortage areas (HPSA) in the state	2018	The Henry J. Kaiser Family Foundation, Mental Health Care HPSA
	Percent of the state's population not living in a U.S. Census Bureau and Health Resources and Services Administration (HRSA) Mental Health Professional Shortage Area	2019	U.S. Census Bureau and HRSA data analyzed by PMO personnel
	Percent of home health episodes of care in the state where the home health team determined whether their patient received a flu shot for the current flu season	2018	CMS Home Health Care State-by-State Data
Home care	Percent of home health episodes of care in the state where the home health team began their patients' care in a timely manner	2018	CMS Home Health Care State-by-State Data
	Number of home health and personal care aides per 1,000 population in the state aged 65 or older	2017	ACS, one-year Public Use Microsample data analyzed by PMO personnel (three-year average)
	State public health laboratory provides or assures testing for air samples	2016	APHL, CLSS

Environmental monitoring	State public health laboratory is certified or accredited by the American Industrial Hygiene Association	2016	APHL, CLSS
	State public health laboratory is certified or accredited by the EPA	2016	APHL, CLSS
	State public health laboratory is certified or accredited by the National Environmental Laboratory Accreditation Conference	2016	APHL, CLSS
	State public health laboratory provides or assures testing for environmental samples in the event of suspected chemical terrorism	2014	APHL, CLSS
	Percent of 12 tests for different contaminants in environmental samples that the state public health laboratory provides or assures, including asbestos, explosives, gross alpha and gross beta, inorganic compounds (e.g., nitrates), metals, microbial, lead, persistent organic pollutants, pesticides (including organophosphates), pharmaceuticals, radon, or volatile organic compounds	2016	APHL, CLSS
	State public health laboratory provides or assures testing for hazardous waste	2016	APHL, CLSS
	State participates in the National Plant Diagnostic Network (NPDN)	2014	NPDN, National Plant Diagnostic website
	Number of environmental scientists and specialists (including health) per 100,000 population in the state	2017	BLS, OES, OES 19-2041
	Number of disease outbreaks in a state due to animal contact per 1 million population	2017	CDC, NORS

Source: National Health Security Preparedness Index

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